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AIR QUALITY IN ONTARIO

1994 COMPREHENSIVE REPORT

DECEMBER 1995

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and Energy

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AIR QUALITY IN ONTARIO

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AIR QUALITY IN ONTARIO
1994 COMPREHENSIVE REPORT

Summary of the Ministry of Environment and Energy Air Quality Data for 1994

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Executive Summary

The Ontario Ministry of Environment and Energy measures air quality data at many locations in the province. These data determine the state of air quality in Ontario and help develop abatement programs to reduce the burden of air pollutants. Ambient air monitoring in Ontario provides information on the actual concentration of selected pollutants in various communities. Air quality data are used in various programs to address key air issues. Table 0-1 below shows the relationship between the air pollutants monitored and current air issues. This report (the twenty-fourth in a series) summarizes air quality in Ontario for 1994.

Air pollution is largely produced by human activity. The pollution in Ontario is due to industrial production, operating automobiles, and other human activities. In addition, a significant amount of pollution is transported by the prevailing wind into southern Ontario from the heavily industrialised midwestern U.S.

Air pollution is also caused to a lesser extent by emissions from natural sources, including plants, volcanic eruptions, forest fires, land and water bodies, radiological decomposition, etc. These emissions can result in natural background air pollution levels. Thus, the ambient air quality levels at a specific location reflect both the human-made and natural contributions.

Air pollutants singly or in combinations can affect human health, damage vegetation and property, and cause other discomfort depending on their concentrations. It is the general practice in presenting air quality data to report on the behaviour of single pollutants. We have followed the same procedure in this report. This report tracks two kinds of trends: air concentrations based on actual direct measurements of pollutant concentrations in the air at selected sites across the province; and emissions, which are estimates of the total tonnage of these pollutants released into the atmosphere annually, based upon the best available engineering calculations.

Table 0-1
Linkages Between Air Pollutants and Air Issues

Issue Pollutant	Ground-Level Ozone	Global Warming	Urban Air Quality	Acid Deposition	Health	Aesthetics
Ozone	x	x	x		x	
Sulphur Dioxide		x	x	x	x	x
Carbon Dioxide			x		x	
Oxides of Nitrogen	x	x	x	x	x	x
VOCs	x	x	x		x	x
Toxic Organics			x		x	
Lead			x		x	
Particulates		x	x	x	x	x
TRS			x		x	x
Manganese			x		x	

Overview of Ministry Programs, Pollutant Trends and Related Air Issues

Over the past 24 years, significant improvements have been achieved in reducing the ambient air pollution levels in Ontario. This is particularly evident for sulphur dioxide (SO2), which has been reduced by 83 per cent.

Sulphur dioxide is mostly emitted by burning fossil fuels and in smelting operations in Ontario. Ontario's Regulation 346, Control Orders on major smelting operations, and the Countdown Acid Rain Program have resulted in the reduction of the SO2 emissions in Ontario from about 3340 kilotonnes in 1971 to about 618 kilotonnes in 1994. A similar trend in the reduction of ambient SO2 concentrations has been recorded.

Other examples of air quality improvements are reflected by significant decreases in average levels of carbon monoxide (82 percent) and suspended particulates (58 percent) over the past 24 years, and in nitrogen dioxide (17 percent) and nitrogen oxides (44 percent) over the past 20 years.

Ground-level ozone and particulates continue to exceed provincial air quality criteria. There has been a decreasing trend in particulate levels in the past 10-20 years. On the other hand, the trend in ground-level ozone levels is more complex. The ozone annual means since 1987 are greater than the annual means recorded during the period 1979 to 1987. However, the total number of annual ozone exceedances of the Ontario 1-hour ambient air quality criterion (AAQC) and the number of occurrences of widespread ozone exceedances are highly variable from year to year and largely reflect variability in weather conditions. Ground-level ozone is not emitted directly into the atmosphere, but rather it is produced primarily by chemical reactions of nitrogen oxides and volatile organic compounds (VOCs) in the presence of sunlight. Oxides of nitrogen are predominantly emitted by the transportation sector. VOCs are generated not only by human activity (28 per cent from the transportation sector, 20 per cent from general solvent use and 16 percent from surface coatings) but are also naturally emitted by trees and vegetation. In addition, significant amounts of ozone and its precursors (nitrogen oxides and volatile organic compounds) are transported into Ontario from the U.S. During hot summer days which favour high levels of ozone, it is estimated that greater than 50 per cent of the ground-level ozone measured in southern Ontario can be attributed to sources in the U.S..

Ontario has several initiatives to reduce ground-level ozone and particulates: the Federal-Provincial NOx-VOC Management Plan, the Federal-Provincial Air Quality Advisory, the Gasoline Volatility regulation, the Stage 1 Vapour Recovery regulation, the Dry Cleaners Training and Certification regulation, the Stationary Combustion Turbine policy, the Voluntary Inspection and Maintenance program and Ontario Hydro's voluntary commitment to reduce NOx emissions by 40 per cent of 1985 base levels by year 2000. However, the number of vehicle kilometres travelled in Ontario is steadily increasing with population and economic growth. It is predicted that this will offset any reductions in the emissions of oxides of nitrogen and hydrocarbons from abatement programs. Pollution prevention is therefore a key element in reducing ozone and particulates.

In 1993, the Ontario Ministry of Environment and Energy, in cooperation with Environment Canada, instituted a program to issue air quality advisories. These are issued in advance for periods of elevated ozone concentrations and urge people to take pollution-reducing action, such as driving less, not using gas powered mowers, etc. Two such advisories were issued in 1994.

The province also has a monitoring program to measure a select group of toxic compounds in urban areas. Results show that ambient concentrations of these compounds are generally very low.

Radiological monitoring is carried out by the Ontario Ministry of Labour and Ontario Hydro in specific regions of the province. The monitored data indicate that the radiological quality of Ontario's air is good.

Current trends from Ontario's acid deposition network indicate that the area of highest wet sulphate deposition (>40 kg/ha/yr) is no longer evident over Ontario, the area of moderately high sulphate deposition (>30-40 kg/ha/yr) has been reduced significantly and the area bounded by 20 kg/ha/yr wet sulphate deposition has not changed significantly over the period 1981 to 1993.

Air quality for major Canadian cities (Toronto, Vancouver and Montreal) has been compared with air quality in selected international cities. Overall, this comparison indicates that, on an international basis, Toronto's air quality is in the middle of the range (for SO2, NO2, CO, O3, TSP, and PM10); however, it is generally worse than the air quality in Vancouver and Montreal. This can be partially attributed to transboundary flow of air pollutants and the more urbanized nature of Toronto.

Increasing concentration of trace gases in the atmosphere are of major concern for such global issues as global warming/climate change and the depletion of the ozone layer. These issues have potential impacts in Ontario. For example, average surface temperatures have increased by about 0.6°C over southern Ontario and by about 0.5°C over northern Ontario since 1890, possibly as a consequence of global warming. In terms of ozone layer depletion, decreases in the total ozone level over Toronto have been noted, averaging about 4 per cent below pre 1980 levels.

Ontario's air quality has shown significant improvement over the years for many pollutants as a result of various abatement programs. Some problems remain for pollutants, such as, ground-level ozone, inhalable particulates and total reduced sulphur compounds. New abatement programs which have been put in place to reduce nitrogen oxides and volatile organic compounds along with pollution prevention activities and negotiations with the U.S. are expected to decrease ozone and particulate levels in the future.

'Table 0-2 summarizes the criteria pollutants according to their characteristics, sources, health and ecological effects and number of sites which exceeded their respective criteria during 1994.

Table 0-2
Overview of Criteria Pollutants

Pollutant	Characteristics	Sources	Ontario Criteria	# Sites Above Criteria/Total # Sites	Health Effects Above Criteria	Ecological Effects Above Criteria
Ozone (O_3)	A colourless gas with a strong smell. Major component of summer smog.	Ozone is not emitted directly into the atmosphere. It is produced by photochemical action on nitrogen oxides and volatile organic compounds.	1 h average 80 ppb	42/45	Irritation of the lungs and difficulty in breathing Exposure to high concentrations can result in chest tightness, coughing and wheezing.	Damage to agricultural crops, ornamental, forests and natural vegetation.
Suspended Particles (SP)	Small particles of solid or liquid matter that stay suspended in air in the form of dust, mist, aerosols, smoke, fume, soot, etc.	Industrial processes including combustion, incineration, construction, metal smelting, etc. Also motor vehicle exhaust. Natural sources such as forest fires, ocean spray and volcanic activity.	24 h average 1.0 COH unit Coefficient of haze unit	27/38	Significant effects for people with lung disease, for asthmatics and people with bronchitis.	Damage to vegetation, deterioration in visibility and contamination of soil.
Total Reduced Sulphur (TRS)	Offensive odours similar to rotten eggs or cabbage	Industrial sources include steel industry, pulp and paper mills and refineries. Natural sources.	1 h average 27 ppb	23/37	Not normally considered a health hazard. They are the primary cause of odours.	
Sulphur Dioxide (SO_2)	Colourless gas with a strong odour similar to burnt matches.	Electric utilities and non-ferrous smelters . Also primary metal processing, iron ore smelters, pulp and paper, petroleum refineries, etc.	1 h average 250 ppb	16/57	Breathing discomfort, respiratory illness, aggravation of existing respiratory and cardiovascular disease. People with asthma, chronic lung or heart disease are most sensitive to SO_2.	Leads to acid deposition which causes lake acidification, corrosion and haze. Damage to tree leaves and crops.
Nitrogen Dioxide (NO_2)	Gas with a pungent and irritating odour.	Automobiles, thermal power plants, incineration, etc. Natural sources include lightning and soil bacteria.	1 h average 200 ppb	0/31	Increasing sensitivity for people with asthma and bronchitis.	Leads to acid deposition: adverse effect on vegetation.
Carbon Monoxide (CO)	Colourless, odourless, tasteless and poisonous gas.	Major source is transportation sector i.e., road vehicles, aircrafts and railways.	1 h average 30 ppm 8 h average 13ppm	0/24 0/24	Impairment of visual perception, work capacity, learning ability and performance of complex tasks.	

Section 1.0
Introduction

Ambient air monitoring in Ontario provides information on the measured concentrations of selected pollutants in various communities throughout Ontario. This information is used for the following purposes:

- Inform the public of their outdoor air quality on a real-time basis so they can respond appropriately to pollutant levels;
- Provide an episode warning and control mechanism for the protection of human health;
- Assess the quality of the air in Ontario and evaluate trends; identify areas of non-attainment and identify the origin of pollutants;
- Assess the effectiveness of pollution abatement activities;
- Provide data for compliance and complaints investigations;
- Trigger immediate compliance action;
- Provide the basis for the development of air management strategies;
- Provide quantitative measurements for abatement action on specific sources;
- Determine the contributions from U.S. sources and their impacts on Ontario;
- Enable the setting of meaningful air quality criteria:
- Provide information on the interaction between the various media;
- Assist in the assessment of ecosystem damage caused by air pollution; support research activities on ecosystem;
- Support other networks.

Emissions generated by human activity as well as the natural emissions of contaminants into the atmosphere on local, regional, continental, and global scales and their atmospheric interactions determine the quality of air at receptor locations. Locally, the air quality at a receptor is often greatly influenced by its proximity to area sources such as automobile emissions and industrial fugitive emissions and to nearby upwind point sources with elevated stack emissions, and existing meteorological conditions. For contaminants that undergo long range transport and transformation such as acidic species, tropospheric ozone, trace metals, etc., distant large sources are significant contributors to local air quality, and the atmospheric interactions are such that levels are strongly linked to synoptic weather patterns and regional scale meteorology. The resultant air quality in Ontario is thus strongly affected by the air emissions due to human activity and meteorology on the various space scales: large scale, mesoscale and local or microscale.

This report (the twenty-fourth in a series) summarizes the state of air quality in Ontario for 1994.

Chapter 2 of this report contains information on the criteria pollutants, results from our public information systems (air quality indices, alerts and advisories) and results from our urban toxics network. In addition, for the first time, information is provided on acid deposition, pollens and radionuclides. Due to serious and prolonged failure of analytical instrumentation, no metal analyses were possible for 1994. It should also be noted that the benzo[a]pyrene results are only available until the end of 1993.

Chapter 3 provides several case study analyses of problem areas in Ontario. These include air particulates in Hamilton and Sault Ste Marie, sulphur dioxide in Sudbury, carbon monoxide levels in Toronto, total reduced sulphur in Fort Frances, and vehicle emissions in downtown Toronto. In addition, Toronto's air quality is compared on an international basis, southern Ontario's air quality is compared with that of northern Ontario, results from a detailed air quality study in Windsor are presented and finally, results from personal exposure studies in Windsor and Hamilton are discussed. The last part of Chapter 3 briefly documents selected abatement measures across Ontario.

In Chapter 4, global air quality issues (global warming/climate change and stratospheric ozone) and their relevance to Ontario are discussed.

Appendix A contains a brief description of the monitoring network operation, quality assurance and quality control procedures and a description of the data base.

Appendix B provides a glossary of the terms used in the report as well as a list of the abbreviations.

Appendix C (Volume 2 in previous reports) provides a description of the monitoring network and, summarizes for each contaminant, the annual statistics including percentiles, maxima, means and exceedances of the Ontario criteria.

A reader response form is found inside the back cover to allow readers to provide feedback to improve future air quality reports.

Section 2.0
Air Quality and Related Environmental Issues

The ambient air quality data and trends presented in this chapter are based on direct measurements. The corresponding annual emission trends are extracted from the Ontario Emission Inventory System (OEIS). Emission estimates for the criteria pollutants from various emitters and emission estimation methodologies are based on the best available information.

With the updated information released by Environment Canada from the transportation model MOBILE 5C and the process information from the industries, a nine year emission trend (1985 to 1994) is presented. Charts and graphs showing emission trends and emission sectors throughout the report are typical of early 1990s emission profiles. Although the total annual emission of each pollutant will vary from year to year, the ranking of sectors in terms of their emission contribution remains fairly constant.

For industrial processes and stationary fuel combustion, sulphur dioxide (SO_2), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO) and particulate matter emissions are estimated from mass balance calculations or computation using standard emission factors adopted by Ontario Ministry of Environment and Energy, Environment Canada and United States Environmental Protection Agency.

For road vehicles (gasoline and diesel powered), NO_x, VOC and CO emissions are estimated from the annual travelled distance of each type of vehicle and from the emission factors in the MOBILE 5C transportation model.

It should be noted, however, that the methods currently in use to obtain emission estimation from sources may have varying degrees of uncertainty, depending on the quality of available source information and accuracy of the applied emission estimation methodologies. It should also be pointed out that emission inventory compilation is a dynamic process. The emission estimates presented are subject to revision whenever more up-to-date methodologies and/or source information become available. Future editions of this report series will show these changes if applicable

Each section of this chapter describes the characteristics, health effects, vegetation effects, ambient air quality criterion/criteria, method of monitoring and trends for a particular pollutant.

Information on acid deposition, aeroallergens and environmental radioactivity has been included in this report for the first time.

Highlights of data collected by the continuous monitoring network during 1994 are shown in Table 2.1.

2.1 OZONE (O_3)

2.1.1 Characteristics

Ozone is a colourless gas and a major component of photochemical oxidant compounds formed as the result of chemical reactions between nitrogen oxides, volatile organic compounds and air in the presence of sunlight. Two characteristics of ozone and oxidant exposures should be noted: (1) ozone itself is a primary cause of many of the health effects reported in toxicological and experimental human studies and the evidence for attributing many health effects to this substance alone is compelling; and, (2) the complex mixture of atmospheric photochemical substances is known to produce health effects, some of which are attributable to pure ozone but may be caused by other photochemical substances and other contaminants in combination with ozone. While the naturally occurring ozone in the stratosphere is beneficial to life by shielding the earth from harmful ultra-violet (UV) radiation given off by the sun, elevated concentrations of ozone at ground level are a major health and environmental concern.

2.1.2 Sources

Ground-level ozone is not emitted directly into the atmosphere in significant amounts, but is produced throughout a complex sequence of photochemical reactions

TABLE 2.1 - HIGHLIGHTS OF THE CONTINUOUS MONITORING NETWORK 1994

	SO_2	SP	TRS	CO	THC	NO_2	NO	NO_X	O_3
LOWEST MEAN	THUNDER BAY	THUNDER BAY	TIVERTON	SUDBURY	MISSISSAUGA	SIMCOE	SIMCOE	SIMCOE	ETOBICOKE
LOCATION/STATION	(63200)	(63046)	(18007)	77203)	(46117)	(22071)	(22071)	(22071)	(35033)
CONCENTRATION	0.00 ppm	0.17 Unit	0.1 ppb	0.1 ppm	1.95 ppm	0.004 ppm	0.001 ppm	0.006 ppm	14.1 ppb
HIGHEST MEAN	CORNWALL	HAMILTON	RED ROCK	TORONTO	ETOBICOKE	TORONTO	TORONTO	TORONTO	LONG POINT
LOCATION/STATION	(56051)	(29102)	(63084)	(31049)	(35033)	(31049)	(31049)	(31049)	(22901)
CONCENTRATION	0.012 ppm	0.59 Unit	3.2 ppb	1.7 ppm	2.29 SP ppm	0.037 ppm	0.052 ppm	0.052 ppm	32.2 ppb
MOST CRITERION EXCEEDANCES - 1 h	15	N/A	250 *	0	N/A	0	N/A	N/A	174
LOCATION/STATION	SKEAD (77012)		RED ROCK (63084)						LONG POINT (22901)
MOST CRITERION EXCEEDANCES - 24 h	0	25	N/A	N/A	N/A	0	N/A	N/A	N/A
LOCATION/STATION		HAMILTON (29102)							
NO. OF STATIONS EXCEEDING 1 h AAQC	16	N/A	23	0	N/A	0	N/A	N/A	42
NO. OF STATIONS EXCEEDING 24 h AAQC	0	27	N/A	N/A	N/A	0	N/A	N/A	N/A
HIGHEST MEASURED VALUE - 1 h									
LOCATION/STATION	COPPER CLIFF (77218)	NANTICOKE (22907)	HAMILTON (29547)	MISSISSAUGA (46110)	OAKVILLE (44015)	WINDSOR (12008)	YORK (36030)	WINDSOR (12008)	LONG POINT (22901)
CONCENTRATION	0.83 ppm	4.9 Unit	355 ppb	16.0 ppm	11.0 ppm	0.18 ppm	0.88 ppm	0.97 ppm	158 ppb
TOTAL NUMBER OF STATIONS	57	38	37	24	5	31	31	31	45

*** Exceedances of pulp mill criterion of 27 ppb for 1-hour.**
Figures in brackets are station number

that require oxides of nitrogen and volatile organic compounds, which are typically emitted from internal combustion engines and other sources, in the presence of sunlight. Ozone is formed downwind of these sources and is capable of travelling long distances throughout the atmosphere and as such, is a manifestation of the long range transport of air pollution and a component of photochemical smog. Its formation and transport are dependent on meteorological factors. Warm temperatures are critical and elevated concentrations generally occur from May to September between noon and early evening. Ozone can also be formed naturally in the atmosphere by electrical discharge and in the stratosphere by solar radiation. The former process does not contribute significantly to urban concentrations of this pollutant. However, there is some evidence that occasionally the intrusion of ozone from the stratosphere can contribute significantly to elevated ground level concentrations of ozone under certain meteorological conditions.

2.1.3 Health Effects of Ozone

Ozone is a pulmonary irritant that affects the respiratory mucus membranes, other lung tissues and respiratory functions. Clinical and epidemiological studies have demonstrated that ozone impairs the normal function of the lungs, causing alterations in respiration rates, the most characteristic being shallow, rapid breathing. Exposure to ozone results in clinical symptoms such as chest tightness, coughing and wheezing. Alterations in airway resistance can occur, especially to those with respiratory diseases (asthma, bronchitis, emphysema). These effects may occur in sensitive individuals as well as in healthy persons exercising vigorously, at concentrations in excess of 120 ppb. However, these effects are presently under review by an expert scientific panel, as some current research indicates that sensitive individuals could be affected at lower concentrations.

2.1.4 Effects on Vegetation

Injury to vegetation is one of the earliest signs of photochemical air pollution, and sensitive plants are useful biological indicators of this type of pollution. Visible signs of these injuries due to ozone are flecking and discolouration of the leaves.

The magnitude of the impact of ozone on agricultural crops, ornamentals, forests and natural vegetation in Ontario is not well documented. This is due primarily to the ubiquity of ozone exposure and the difficulty of assessing plant growth over entire growing seasons and under ozone exposure dynamics that vary extensively from location to location and from year to year. Adding to these difficulties is newly emerging science which indicates that visual symptoms on plants do not provide an accurate measure of crop yield impact and information which demonstrates that crop yield can be reduced in the absence of leaf damage.

In earlier studies by the Ministry, it was estimated that crop and ornamental losses due to ozone impacts in Ontario ranged from $16-70 million annually. This estimate was based primarily on work in the U.S., where crops were experimentally exposed to ozone under controlled open-top field chambers. It is now believed that some of the experimental conditions and interpretative methodologies used in the U.S. program failed to reflect real world exposure conditions and to control factors which could influence plant response; therefore the results may not accurately reflect true crop response under a variety of ambient exposure scenarios.

In the case of forests, the science is further complicated by many other factors that affect tree growth and survival in a dynamic ecosystem, where trees compete for sunlight, moisture and nutrients.

From an ecological impact, only a cursory level of vegetation monitoring is conducted throughout major crop protection areas of southern and southwestern Ontario. This provides us with an estimate of foliar injury severity on a few sensitive crops, but it is not sufficient to answer more important questions related to the economic impact on crop or forest productivity.

The current ambient air quality

FIGURE 2.1.1

Trend of Ozone Exceedances in Ontario

(1979 - 1994)

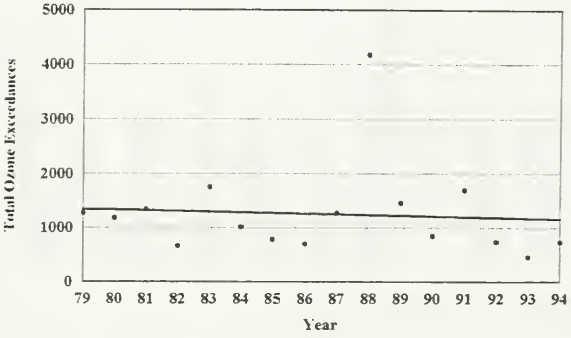
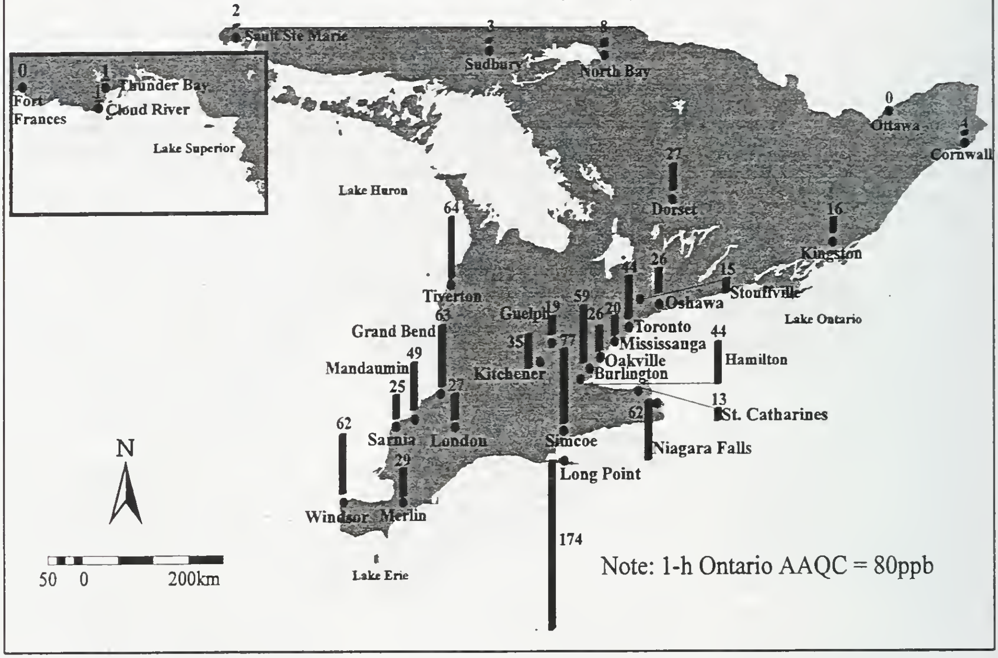


FIGURE 2.1.2

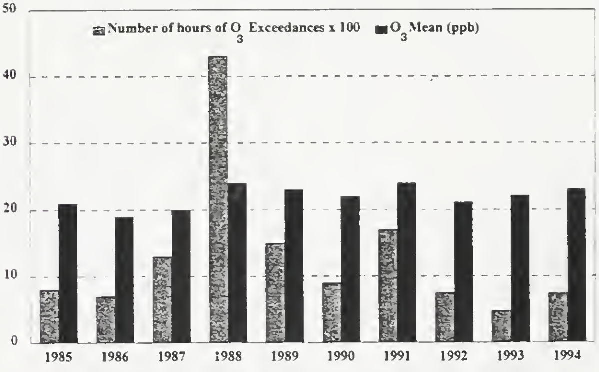
Geographical Distribution of 1-Hour Ozone Exceedances Across Ontario (1994)



Note: 1-h Ontario AAQC = 80ppb

FIGURE 2.1.3

10-Year Trend for Ozone



Note: 23 sites operated over 10 years

criterion for ozone in Ontario is 80 ppb. It was established in the early 1970s, and was based on protecting most sensitive plants from ozone injury. At that time, this level of protection was considered adequate to protect against both vegetation damage and impacts on human health. It is under review via the Multi-stakeholder Federal NO_x/VOC Management Plan and some of the current research is indicating that there may not be a human health effect threshold for this pollutant. As part of the federal/provincial air quality objective review, the vegetation component is also being examined, and this analysis also points to the possibility of negative growth and productivity impacts on sensitive plants/crops at ozone levels below the existing 1 hour ambient air criterion.

FIGURE 2.1.4

ONTARIO VOC EMISSION TREND

(1985 to 1994)

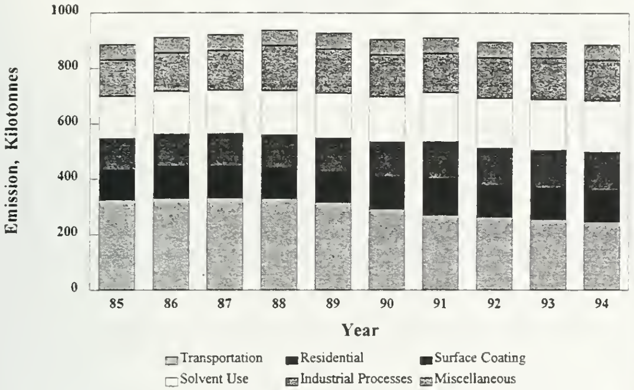


FIGURE 2.1.5

Ontario VOC Emissions by Sectors

(Emissions from Human Activity, Early 1990s)

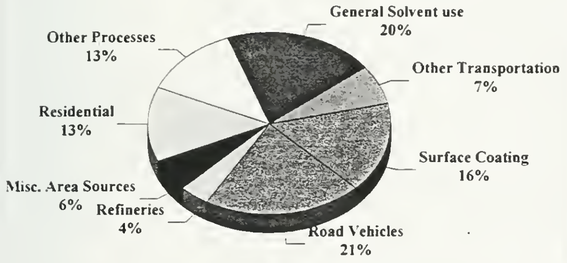
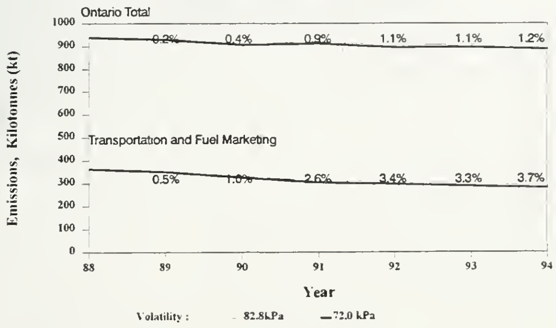


FIGURE 2.1.6

Reduction in Ontario VOC Emission Due to Lower Gasoline Volatility in Summer



Emissions from road vehicles are estimated from MOBILE 5C emission factors.
1989 and onwards : Use of 72.0 kPa gasoline in summer months

2.1.5 Ontario (AAQC)

80 ppb (1-hour)

2.1.6 Method of Monitoring

Chemiluminescence emission spectroscopy and UV absorption photometry are used to monitor for ozone.

In the first method, an air sample reacts with ethylene to emit visible light (chemiluminescence) of intensity directly proportional to the ozone concentration. In the second method, ozone absorption of UV light changes the intensity of the light beam, attenuation is in proportion to the concentration of the ozone.

2.1.7 Location of Monitors

Appendix C provides a description of the provincial O_3 network. Ozone monitoring was carried out at 45 locations in 1994.

2.1.8 Ozone in Ontario

In Ontario, the highest concentrations of ground-level ozone in southern Ontario are recorded on hot sunny summer days. Emissions of oxides of nitrogen and volatile organic compounds, key chemicals responsible for the production of ground-level ozone, also tend to increase with higher temperatures. Higher temperatures in summer are typically associated with slow moving high pressure weather systems which bring warm air into the province from the south and also allow pollutant concentrations to build up over a number of days. When the centre of the high pressure system is located south of the lower Great Lakes, ozone along with its precursors (NO_x and VOCs) is transported into Ontario. A large contribution (50 per cent or greater) to the ground-level ozone concentrations observed in Ontario can be attributed to long range transport of ozone and its precursors from neighbouring industrial states south of the Great Lakes.

2.1.9 Monitoring Results (1994)

The distribution by percentile of the hourly data, the mean, and the maximum one-hour and 24-hour values are provided in Appendix C. Also given are the number of exceedances of the ozone AAQC.

At urban sites the lowest annual mean (14.1 ppb) was measured at the Etobicoke South monitor (35033). Urban locations, because of the scavenging of ozone by nitric oxide and other pollutants, record lower levels of ozone than rural locations. The lowest annual mean (24.6 ppb) for rural sites was recorded at Mandaumin.

The highest annual mean concentration (32.2 ppb) at ground level was measured at Long Point (22901) on the northern shore of Lake Erie. The greatest number of 1-hour exceedances (174), the highest 24-hour maximum value (96 ppb) and the highest 1-hour maximum value (158 ppb) were also measured at Long Point.

Among urban sites, Windsor University (12008) recorded the highest 1-hour mean concentration (139 ppb). The greatest number of 1-hour exceedances (62) was recorded at Windsor College (12016), the highest annual mean (27.1 ppb) was recorded at Sudbury (77203) and the highest 24-hour mean (82 ppb) at Burlington (44008) during 1994.

2.1.10 Exceedances of Ontario's 1-hour AAQC

Figure 2.1.1 shows the number of ozone exceedances of the 1-hour AAQC (80 ppb) recorded at 23 long term monitoring sites across Ontario during the period 1979-1994. The total number of hours of exceedances of the Ontario criterion recorded in 1994 at these long term ozone sites in Ontario was 740. This number of

FIGURE 2.1.7

Trend of Ozone Annual Means all sites across Ontario (1979 -1994)

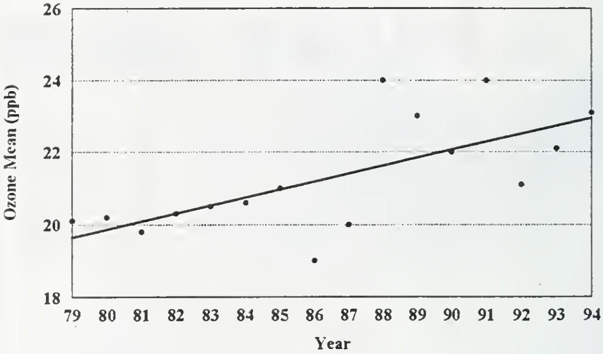


FIGURE 2.1.8

Trend of Ozone Annual Means Rural Sites (1979 - 1994)

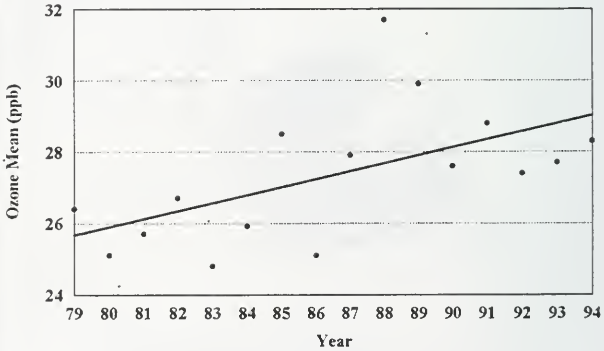


FIGURE 2.1.9

Trend of Ozone Annual Means Urban Sites (1979 -1994)

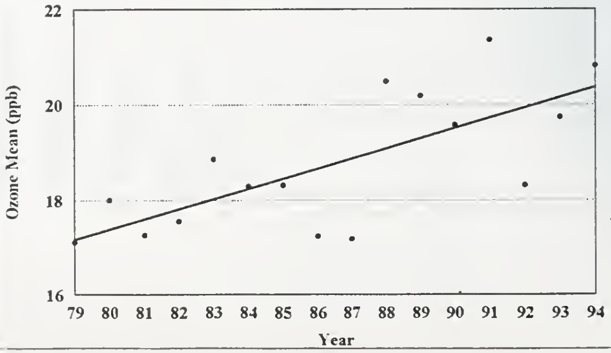


FIGURE 2.1.10

Trend of Ozone Exceedances During the Last 10 Years Rural Sites (1985 - 1994)

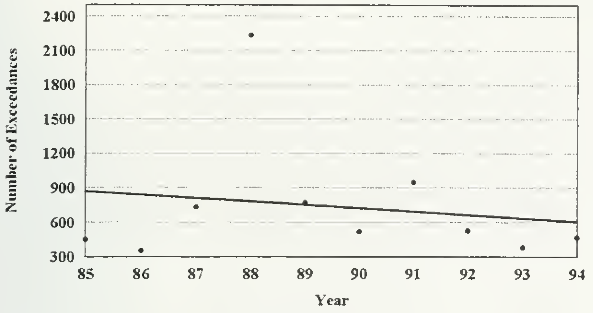


FIGURE 2.1.11

Trend of Ozone Exceedances During the Last 10 Years Urban Sites (1985 - 1994)

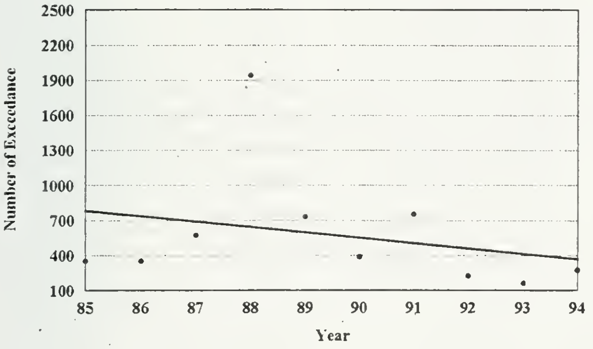
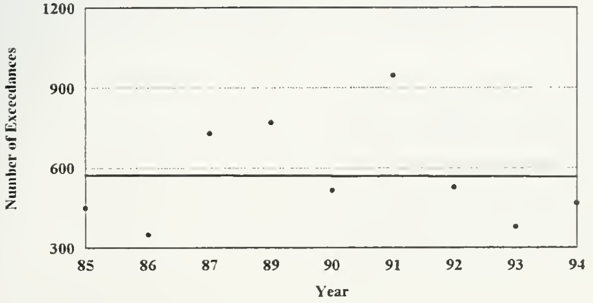


FIGURE 2.1.12

Trend of Ozone Exceedances Rural Sites with 1988 Removed (1985 - 1994)



exceedances is greater than the number recorded at these sites during 1993 (namely,480) but is less than 20 per cent of the exceedances recorded in 1988. The number of exceedances of the AAQC during any given year, is largely a reflection of the prevailing meteorological conditions. Meteorological conditions conducive to the production of high levels of ozone were less frequent in 1994 than in 1988. The geographical distribution of 1-hour ozone exceedances across Ontario during 1994 is shown in Figure 2.1.2. Long Point on the northern shore of lake Erie recorded the greatest number of exceedances (174).

During years that a large number of exceedances of the AAQC for ozone is recorded, Ontario typically experiences heat waves with multi-day events of high temperatures coupled with long hours of bright sunshine, essential conditions for the photochemical production of high ozone concentrations. Extended periods of high daytime temperatures by themselves, however, do not necessarily lead to high ozone concentrations. Other meteorological factors are also critical. For example, a comparison of the summers of 1988 and 1993 during a similar 5-day July period of temperatures above 30°C in downtown Toronto showed higher relative humidities, more measurable precipitation and less bright sunshine in 1993. These differing meteorological conditions likely contributed to the result that there were far fewer elevated ozone levels in 1993 at the 7 Toronto sites, 17 hours compared to 199 hours in 1988.

2.1.11 Trends in Ozone

The 10-year trend in mean annual ozone levels and number of exceedances of the provincial 1-hour AAQC (80 ppb) for 23 ozone sites (1985-1994) are displayed in Figure 2.1.3 and Table 2.1.1. The high ozone concentrations in 1988 are likely attributed in part to hot, dry, stagnant, summertime conditions (high temperatures and strong solar insolation). The interpretation of the 10-year ozone trends is difficult due to the compounding factors of meteorology and emission changes. Just as the high number of 1-hour ozone exceedances (4345) in 1988 are likely attributed, in part, to the meteorological conditions, the low number of ozone exceedances (480) in 1993 are likely due, in part, to meteorological conditions being less favourable for the production of elevated ozone concentrations.

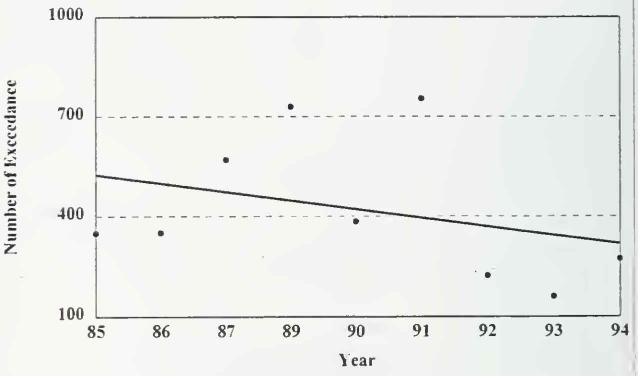
There is little variation in the VOC emission trend for the period 1985 to 1994 (Figure 2.1.4). As a result of new vehicle emission standards and the economic slowdown, emissions from the transportation sector showed a slight decrease from 1989 to 1994 (Figure 2.1.4). On the other hand, there is a slight upward trend for general solvent usage and surface coating over the same period. Emissions from forest fires and natural sources are not included in the trend; these emissions may be as high as three times the anthropogenic sources.

The introduction of lower gasoline volatility (from 82.8 kPa to 72.0 kPa) beginning in 1989 for the summer months has resulted in further VOC emission reduction in addition to the new vehicle standards. Ontario's VOC emissions by sectors are shown in Figure 2.1.5. Road vehicles and other transportation account for approximately 28 per cent of the emissions. It is estimated that lowering the gasoline volatility has reduced provincial VOC emissions by 1.2 per cent in 1994 (Figure 2.1.6).

The impact of changes in VOC emissions, as a precursor, on ozone production is not obvious from the trend of O_3 for 1989 to 1994. The number of O_3 exceedances during the 1989 to 1994 period was comparable to, or higher than, the results during 1983 to 1987 when the gasoline volatility was 82.8 kPa. Any trend in ozone during 1989 to 1994 can be attributed mostly to meteorological variability as was the case in 1988.

FIGURE 2.1.13

Trend of Ozone Exceedances Urban Sites with 1988 Removed (1985 - 1994)



The trend of the annual means for the 23 (16 urban and 7 rural) long term ground-level ozone monitoring sites across Ontario, during the period 1979-1994, is shown in Figure 2.1.7. It shows that there has been an increasing trend in the annual means during the period. There was an increase of 20 per cent from 1987 (20 ppb) to 1988 (24 ppb). After 1987 all of the annual means are larger than those recorded from 1979 to 1987. The lowest annual mean during the 1988-1994 period was 21 ppb and was recorded in 1992. The 1994 annual mean is approximately 4 per cent higher than in 1993. Over the 10 year period 1985-1994 annual means have increased by approximately 1.4 per cent per annum and over the longer period 1979-1994 the increase has been approximately 1.0 per cent per annum.

Figures 2.1.8 and 2.1.9 show the trend of the annual means at the 7 rural and 16 urban long term monitoring sites respectively during the 10-year period 1985-1994. They show that there is an increasing trend at both rural and urban sites. Note that the highest annual mean, during the period, at the rural sites was recorded during 1988 whereas, the highest at urban sites was recorded during 1991. The trends of the number of yearly exceedances of Ontario's AAQC of 80 ppb at the rural and urban sites during the period 1985-1994 are shown in Figures 2.1.10 and 2.1.11. The figures show that the number of exceedances has been declining at both rural and urban sites. However, when the graphs are redone with the 1988 data removed (1988 is considered an atypical year for ozone exceedances), the rural sites plot (Figure 2.1.12) shows that the slope of the trend line is approximately zero, indicating that the exceedances have remained relatively unchanged during this period. However, the plot for the exceedances at the urban sites shows a declining trend (Figure 2.1.13). This however, does not appear to be significant.

Table 2.1.1
10-YEAR TREND FOR O_3
Annual Mean (ppb)

City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CORNWALL	25.8	22.8	20.8	24.0	20.4	21.2	20.7	20.8	21.6	21.7
ETOBICOKE	18.1	16.7	16.0	19.3	16.9	16.4	19.0	15.4	16.0	17.4
HAMILTON	19.0	16.4	16.2	17.9	16.7	17.6	19.9	16.9	16.4	17.0
GRAND BEND***	26.5	26.1	25.9	29.7	28.0	27.4	n/a	29.7	31.3	30.2
KITCHENER	19.9	17.0	17.1	21.6	19.9	n/a	27.2	22.7	23.2	24.4
LONDON	21.3	18.4	19.4	23.7	22.9	22.1	22.7	20.3	22.8	23.1
LONG POINT	34.4	31.4	31.7	38.4	35.7	33.0	33.9	32.3	31.2	32.2
MANDAUMIN	27.9	23.1	25.9	30.0	28.4	23.7	28.1	23.5	24.5	24.6
MERLIN	22.0	19.8	27.3	31.5	27.2	26.0	28.4	24.3	23.7	24.2
MISSISSAUGA	16.0	15.7	14.5	17.7	18.6	17.8	18.6	15.6	16.1	19.5
NORTH YORK**	11.8	7.4	8.9	9.0	12.8	13.3	14.7	16.3	18.1	18.8
OAKVILLE	19.6	18.5	19.8	20.9	22.1	22.2	22.1	19.3	21.0	22.5
OSHAWA	18.2	17.2	17.9	20.2	21.9	18.8	22.6	20.3	21.4	23.8
OTTAWA	19.2	17.3	16.1	20.7	20.9	21.5	20.8	17.4	18.1	19.7
SARNIA	22.9	20.9	21.8	22.6	25.3	21.4	23.4	21.3	22.6	21.4
SCARBOROUGH	13.9	16.6	16.8	17.7	17.9	17.6	19.1	14.3	17.0	18.2
SIMCOE	30.6	27.6	28.4	31.2	28.6	26.3	29.1	25.1	27.8	30.2
ST CATHARINE	17.9	21.9	n/a	23.6	20.8	23.8	25.0	19.3	23.9	23.6
STOUFFVILLE	23.3	20.0	22.9	26.6	28.1	24.9	25.0	23.0	23.0	25.3
SUDBURY*	13.4	17.1	19.4	29.5	28.9	27.2	27.0	25.4	25.9	27.1
TIVERTON	34.6	27.5	33.0	34.6	33.1	31.3	34.2	33.4	32.1	31.7
TORONTO	17.1	16.2	15.4	17.5	16.9	15.7	18.0	12.5	14.6	16.9
WINDSOR	19.7	17.4	17.6	23.5	20.6	17.1	17.6	15.1	17.1	18.0
COMPOSITE MEAN	**21.4**	**19.7**	**20.6**	**24.0**	**23.2**	**22.1**	**23.5**	**21.1**	**22.1**	**23.1**

*Site changed from downtown Ash Street to Sudbury Science Centre North

**Site changed location from Science Centre (34002) to North York Central (34020)

***Site changed location from Huron Park(10001) to Grand Bend (15020)

n/a - data not available

2.2 SULPHUR DIOXIDE (SO_2)

2.2.1 Characteristics

SO_2 is a colourless gas with a strong, pungent odour at concentrations over 0.5 ppm. Sulphur dioxide can be oxidized (either photochemically or in the presence of a catalyst) to sulphur trioxide (SO_3), which in the presence of water vapour is readily converted to sulphuric acid mist. These airborne gaseous pollutants are collectively called sulphur oxides (SO_x). Other basic oxides combine with SO_3 to form sulphate aerosols. Sulphuric acid droplets and other sulphates are thought to account for about 5 to 20 per cent of the total suspended particulate in urban air. These compounds can be transported over large distances and return to earth as a major constituent of acid deposition. Many of the health problems attributed to SO_2 may be the result of the oxidation of SO_2 to other compounds.

2.2.2 Sources

Industrial processes are the major sources of sulphur dioxide emissions in Ontario. Based on 1994 estimates, the electric utilities and non-ferrous smelters contributed approximately 53 per cent of the total SO_2 emissions, 36 per cent from other industrial sources such as primary metals processing, petroleum refineries, iron-ore smelters and pulp and paper, etc. Area sources, including transportation and space heating, accounted for 11 per cent of the total emissions. (Figure 2.2.1).

2.2.3 Health Effects

At levels exceeding the Ontario AAQC, SO_2 can adversely affect both human health and vegetation. Human health effects include breathing discomfort, respiratory illness, alterations in the lung's defense and aggravation of existing respiratory and cardiovascular disease. Major subgroups of the population most sensitive to SO_2 include asthmatics and individuals with chronic lung disease or cardiovascular disease. It has been shown that SO_2 inhaled through the mouth produces greater effects than air breathed through the nose (mucus in the upper respiratory tract absorbs most of the gas). People with pre-existing respiratory problems are more susceptible to SO_2 damage because of the greater percentage of air that they breathe is through the mouth. The gas thus penetrates into the lungs and becomes an irritant of the lower respiratory tract.

There are some preliminary results (Urban Air Group at McMaster University, Hamilton, Ontario) indicating a relationship between SO_2 and hospital admissions.

2.2.4 Effects on Vegetation

The effects of sulphur dioxide on vegetation are historically the best known of the phytotoxic gases. Depending upon the concentration of the gas, duration of the fumigation, plant species and predisposing factors, sensitive plant foliage can suffer acute or chronic injury from sulphur dioxide. Both native and cultivated plant species can be injured in the vicinity of point sources (i.e., smelters or fossil-fuelled generating stations) or from accidental releases.

2.2.5 Ontario AAQC

0.25 ppm (1-hour)- based on vegetation effects

0.10 ppm (24-hours)- based on health effects

0.02 ppm (1-year)- based on vegetation effects.

2.2.6 Method of Monitoring

The fluorescence of SO_2 excited by pulsed ultra-violet radiation is the method used.

2.2.7 Location of Monitors

Appendix C provides a description of the provincial SO_2 network. SO_2 monitoring was conducted at 57 locations in 1994.

FIGURE 2.2.1

Ontario Sulphur Dioxide Emissions by Sectors
(Emissions From Human Activity - 1994 Estimate)

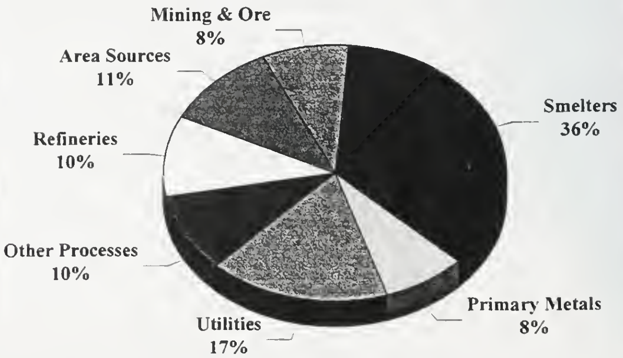
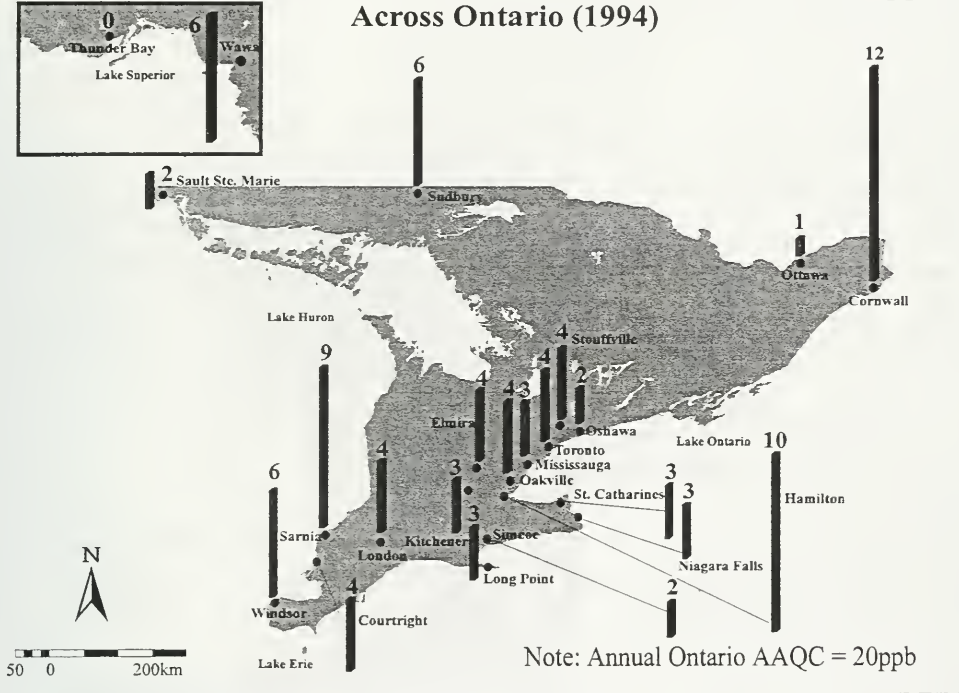


FIGURE 2.2.2

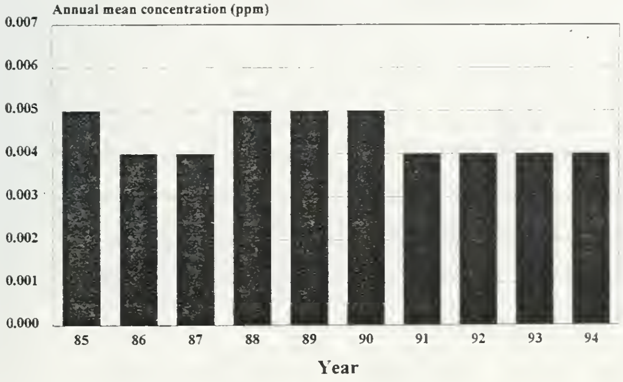
Geographical Distribution of Annual SO2 Concentrations (ppb) Across Ontario (1994)



Note: Annual Ontario AAQC = 20ppb

FIGURE 2.2.3

10-Year Trend for SO2



Note: 25 Sites operated over 10 years

2.2.8 Monitoring Results

The distribution by percentile of the hourly data, the annual average, and the maximum one-hour and 24-hour (midnight to midnight) values are provided in Appendix C. Also given are the number of exceedances of the sulphur dioxide criteria.

The lowest annual average SO_2 level in the province was measured in Thunder Bay (63200), where the annual mean SO_2 level was close to 0.00 ppm.

The highest annual mean (0.012 ppm) was recorded at the Cornwall site (56051), the greatest number of exceedances (15) of the 1-hour AAQC at Skead in Sudbury and, the maximum 24-hour concentration (0.10 ppm) at the Copper Cliff site (77218), also in Sudbury.

Throughout the province there

was a total of 16 SO_2 stations (13 in the Sudbury basin area) where the hourly SO_2 criterion was exceeded at least once during 1994. There were no exceedances of the 24-hour criterion or the annual criterion during 1994. (See Table 2.1). The geographical distribution of annual SO_2 concentrations (ppb) across Ontario in 1994 is shown in Figure 2.2.2. This mapping shows that the centres with the stronger emission sources such as Hamilton, Cornwall and Sarnia recorded the highest annual SO_2 levels. Concentrations in Cornwall have increased by about 140 per cent during the period 1992 to 1994.

2.2.9 Trends in SO_2

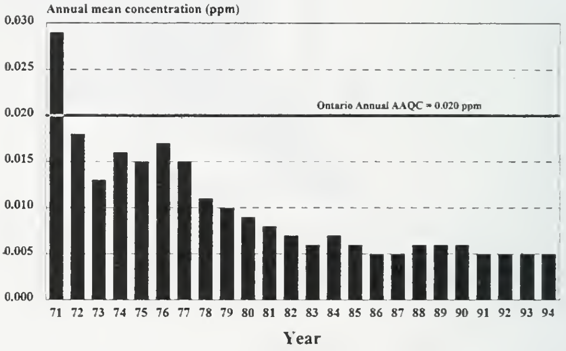
The 10-year trend in mean ambient SO_2, 1985 to 1994, is presented in Figure 2.2.3 and Table 2.2.1 for twenty-five sites which possess a continuous ten-year record. Over the period 1971 to 1994 there has been an 83 per cent improvement in annual mean SO_2 concentrations (see Figure 2.2.4). From 1985 to 1991 there was a 20 per cent decrease in mean concentrations. However, after 1991, concentrations have remained relatively unchanged. The majority of monitors in Ontario's urban centres meet the provincial 1-hour objective (0.25 ppm). Of the 16 stations which exceeded the provincial 1-hour SO_2 AAQC in 1994, 13 were located in the Sudbury basin. The INCO and Falconbridge smelting operations are responsible for the large number of 1-hour exceedances in the Sudbury area.

Most of the SO_2 emissions are from the large point sources in Ontario. Figure 2.2.1 shows that the non-ferrous smelters contributed about half of the SO_2 emissions. With the introduction of tighter emission controls, the use of low sulphur fuel and the Countdown Acid Rain program, SO_2 emissions show a downward trend over the period 1970 to 1994 (Figure 2.2.5). The relatively lower emissions in 1978, 1979, 1982 and 1983 resulted from production shutdown/decreases at the Sudbury smelters. In 1994, the emissions from electric utilities were 106 kilotonnes which is below the 1994 Countdown limit of 175 kilotonnes. Total SO_2 emissions were approximately 58 per cent less than emissions in 1985. It should be noted that the 1994 Ontario SO_2 emission total is about 618 kilotonnes which is well below the 1994 countdown limit of 885 kilotonnes.

There is a close connection between SO_2 emissions, local ambient air quality concentrations and the deposition of sulphur compounds in rain and snow which acidify our lakes and streams. The downward 10-year trend in Ontario's SO_2 emissions is helping to meet the deposition target of 20 kg/ha/yr of wet sulphate. This is believed to be a level that will protect all but the most sensitive lakes. Approximately 50 per cent of the acid rain affecting Ontario comes from the United States.

FIGURE 2.2.4

Long Term Trend for SO_2



Note: 12 Sites operated over 24 years

FIGURE 2.2.5

Ontario Sulphur Dioxide Emission Trend (1970 to 1994)

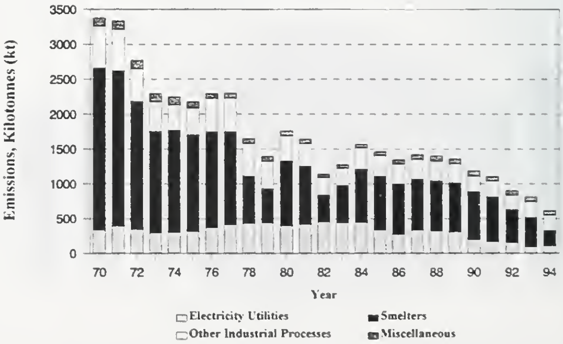


Table 2.2.1
10-YEAR TREND FOR SO_2
Annual Mean (ppm)

City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
BURLINGTON	0.004	0.004	0.004	0.004	0.007	0.006	0.003	0.006	0.006	0.004
CORNWALL	0.009	0.008	0.006	0.006	0.007	0.005	0.005	0.005	0.007	0.012
ETOBICOKE	0.007	0.005	0.005	0.006	0.005	0.006	0.006	0.008	0.005	0.004
HAMILTON	0.009	0.008	0.007	0.008	0.01	0.007	0.007	0.007	0.006	0.005
KITCHENER	0.002	0.003	0.004	0.003	0.003	n/a	0.003	0.003	0.003	0.003
LONDON	0.002	0.003	0.003	0.004	0.006	0.004	0.005	0.004	0.003	0.004
LONG POINT	0.002	0.002	0.002	0.002	0.003	0.004	0.004	0.005	0.002	0.003
MISSISSAUGA	0.006	0.007	0.009	0.004	0.004	0.004	0.005	0.006	0.003	0.003
NIAGARA FALLS	n/a	0.003	0.003	0.002	0.005	0.005	0.005	0.005	0.004	0.004
NORTH YORK*	0.008	0.005	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.003
OAKVILLE	0.006	0.005	0.003	0.005	0.006	0.005	0.005	0.004	0.005	0.004
OSHAWA	0.003	0.003	0.004	0.006	0.006	0.004	0.004	0.004	0.003	0.002
OTTAWA	0.002	0.002	0.001	0.002	0.003	0.002	0.003	0.002	0.002	0.001
SARNIA	0.011	0.008	0.007	0.009	0.008	0.012	0.009	0.009	0.01	0.009
SCARBOROUGH	0.003	0.003	0.004	0.008	0.006	0.006	0.004	0.003	0.003	0.003
SIMCOE	0.005	0.003	0.003	0.005	0.005	0.004	0.003	0.003	0.003	0.002
ST CATHARINES	0.006	0.005	0.01	0.011	0.006	0.004	0.005	0.005	0.003	0.003
STOUFFVILLE	0.004	0.002	0.002	0.003	0.004	0.003	0.004	0.003	0.003	0.004
SUDBURY	0.010	0.008	0.009	0.01	0.008	0.008	0.005	0.004	0.004	0.003
THUNDER BAY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TIVERTON	0.002	0.001	0.001	0.003	0.002	0.001	0.001	0.001	0.001	0.002
TORONTO	0.004	0.004	0.004	0.007	0.008	0.006	0.005	0.008	0.007	0.003
WINDSOR	0.007	0.008	0.008	0.011	0.008	0.007	0.007	0.006	0.006	0.006
COMPOSITE MEAN	**0.005**	**0.004**	**0.004**	**0.005**	**0.005**	**0.005**	**0.004**	**0.004**	**0.004**	**0.004**

* Site changed location from Science Centre (34002) to North York Central (34020) in 1992.

n/a - data not available

2.3 TOTAL REDUCED SULPHUR COMPOUNDS (TRS)

2.3.1 Characteristics

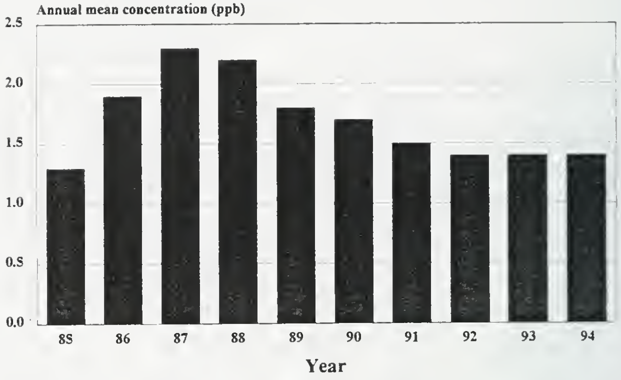
The characteristics of TRS are offensive odours similar to rotten eggs or rotten cabbage.

2.3.2 Sources

The industrial sources include the steel industry, pulp and paper mills, and refineries. The natural sources include swamps, bogs, and marshes.

FIGURE 2.3.1

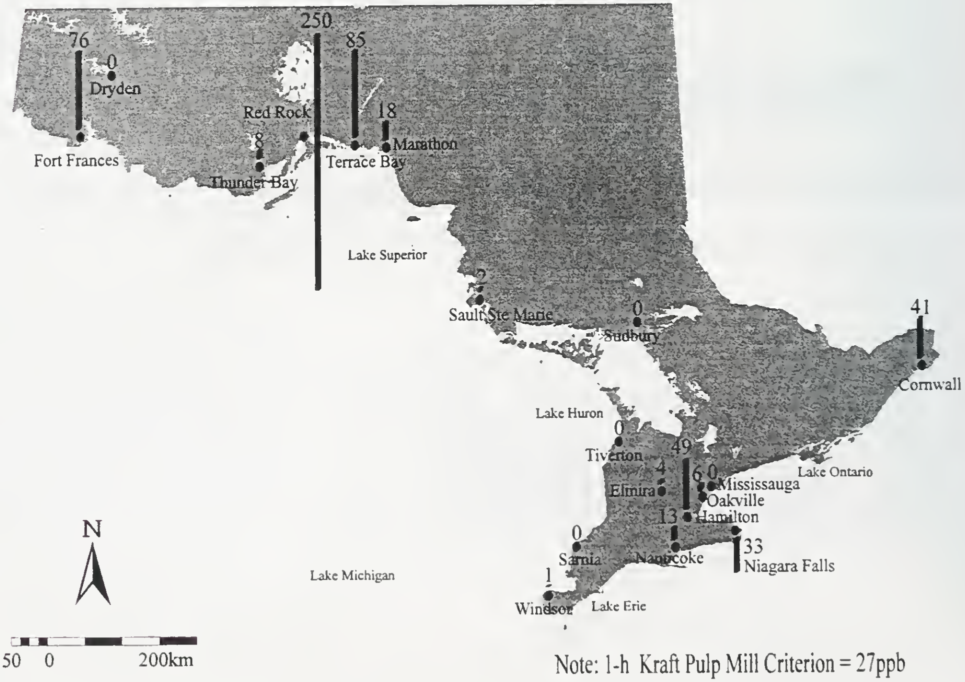
10-Year Trend for TRS



Note: 6 Sites operated over 10 years

FIGURE 2.3.2

Geographical Distribution of TRS 1-Hour Exceedances of the Kraft Pulp Mill AAQC Across Ontario (1994)



Note: 1-h Kraft Pulp Mill Criterion = 27ppb

2.3.3 Effects

1 hour average

less than 5 ppb- no known effects
5 ppb- odour threshold
27 ppb- extremely odourous
1,000 ppb- sensitive individuals may suffer nausea and headache due to severe odour.

2.3.4 Ontario AAQC

Methyl Mercaptans-10 ppb (1-h)
Hydrogen Sulphide-20 ppb (1-h)
TRS (from Kraft Pulp Mills)- 27 ppb (1-h).

2.3.5 Method of Monitoring

Reduced sulphur compounds are oxidized to SO_2 in a high temperature converter and the resulting SO_2 concentration is measured using fluorescent excitation by ultra-violet radiation.

2.3.6 Location of Monitors

Appendix C provides a description of the provincial TRS compounds network. TRS monitoring was carried out at 37 locations in 1994.

2.3.7 Monitoring Results

The distribution by percentile of the hourly data, the annual average, and the one-hour and 24-hour maxima during 1994 are provided in Appendix C.

The lowest average level (0.1 ppb) measured in the province was at Tiverton (18007) on the eastern shore of Lake Huron. The highest annual mean (3.2 ppb) and the greatest number of exceedances (250) of the 1-hour TRS pulp mill AAQC was recorded at Red Rock (63084). The highest 1-hour value (355 ppb) was recorded at Hamilton (29547) (See Table 2.1).

Twenty-three sites (62 per cent) exceeded the 1-hour kraft pulp mill criterion during 1994. Note that all sites are not in the vicinity of kraft pulp mills.

2.3.8 10-Year Trend in TRS

Table 2.3.1 shows the ten-year trend in mean annual TRS for selected Ontario cities while Figure 2.3.1 shows that the lowest provincial mean occurred in 1985 followed by a general decreasing trend for 1987 to 1991 and then a general levelling off from 1992 to 1994. The minimum in 1985 is due to production shutdowns/ decreases at the kraft pulp mill in Cornwall and to the use of monitors which underestimated TRS levels in Fort Frances.

The spatial distribution of provincial TRS levels is displayed in Figure 2.3.2. In this figure the number of exceedances of the 1-hour kraft pulp mill criterion (27 ppb) is shown for cities/towns across Ontario. As expected, the highest number of exceedances is recorded in communities which have kraft pulp mills (i.e., Fort Frances, Cornwall, Terrace Bay, Thunder Bay, Red Rock and Marathon). On occasion, TRS 1-hour exceedances are recorded in Windsor, Hamilton, Oakville, Mississauga and Sault Ste Marie. Elevated levels of TRS in these locations are usually due to iron and steel or refinery operations.

Table 2.3.1
10-YEAR TREND FOR TRS
Annual Mean (ppb)

City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CORNWALL	0.8	2.6	4.3	2.5	3.4	3.4	2.9	2.3	1.8	2.5
FORT FRANCES	2.0	3.9	5.5	5.9	4.9	5.5	4.3	4.2	4.2	2.4
HAMILTON	1.4	1.4	0.9	0.8	0.8	0.9	0.8	0.6	0.7	1.1
MARATHON	1.3	2.1	2.0	2.2	1.5	1.1	0.9	0.5	0.7	0.9
OAKVILLE	2.4	2.4	1.6	1.4	1.1	1.3	1.6	0.5	1.0	1.3
RED ROCK	1.9	1.9	2.7	2.9	1.4	1.7	1.4	2.0	1.9	3.2
TERRACE BAY	1.4	1.5	2.4	2.1	1.4	1.3	1.3	1.7	1.7	1.1
TIVERTON	0.1	0.1	0.4	0.9	0.4	0.0	0.0	0.1	0.1	0.1
THUNDER BAY	0.8	1.0	0.8	1.0	1.0	0.2	0.2	0.3	0.2	0.3
COMPOSITE MEAN	**1.3**	**1.9**	**2.3**	**2.2**	**1.8**	**1.7**	**1.5**	**1.4**	**1.4**	**1.4**

2.4 NITROGEN DIOXIDE (NO_2)

2.4.1 Characteristics

Nitrogen (N_2) is an abundant and inert gas which makes up almost 80 per cent of the earth's atmosphere. In this form, it is harmless to mankind and essential to plant metabolism. It is a frequent component in many combustion processes due to its abundance in the air. When combustion temperatures are extremely high, as in the burning of coal, oil, gas and in automobile engines, atmospheric nitrogen (N_2) may combine with O_2 to form the various oxides of nitrogen (NO_x). Of these, nitric oxide (NO) and nitrogen dioxide (NO_2) are the most important contributors to air pollution.

NO_2 is a reddish-brown gas with a pungent and irritating odour over 0.10 ppm. It is an oxidation product of nitric oxide (NO) which is the primary NO_x emission. NO_2 reacts with hydrocarbons in sunlight to form ozone, and may be further oxidized to form nitric acid, a component of acid rain.

2.4.2 Sources

Anthropogenic sources of NO_x include automobiles, thermal power plants, incineration and several industrial processes. In Ontario, the transportation sector accounts for about 66 per cent of total NO_x emissions. A further 22 per cent of total emissions are from major combustion processes including power generation, smelters and primary metal processing (Figure 2.6.3).

The natural sources of NO_x emissions include lightning and soil bacteria. These natural emissions of NO_x are small compared to the anthropogenic emissions.

2.4:3 Effects

1 hour average

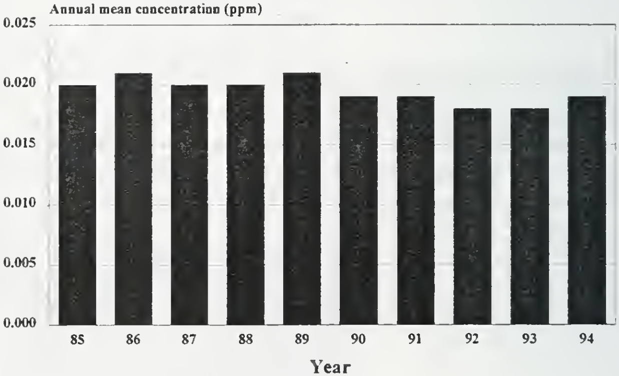
less than 0.10 ppm- no known effects although it may contribute to ozone and acid rain production.
0.10 ppm- odour threshold
0.25 ppm- some increase in bronchial reactivity in asthmatics
0.52 ppm- increasing sensitivity to individuals with asthma and bronchitis.

Clinical studies reveal that odours are perceived at levels between 0.10 and 0.20 ppm for a few minutes. Epidemiological studies have indicated that children are susceptible to changes in pulmonary function which is induced by chronic exposure to NO_2 concentrations of 0.10 ppm for a few minutes.

NO_2 also has an effect on materials (i.e., corrosion of metals, fading of fabric dyes, degradation of rubber, etc.) and an adverse effect on vegetation.

FIGURE 2.4.1

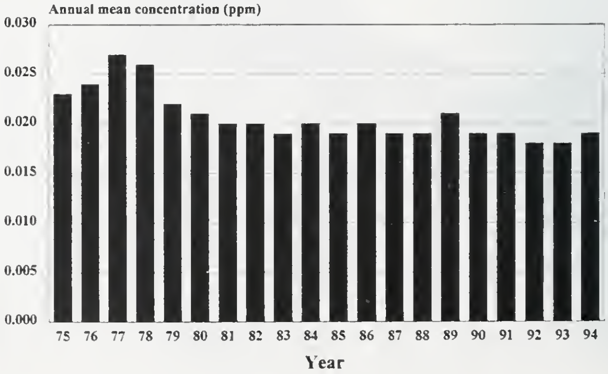
10-Year Trend for NO_2



Note: 17 Sites operated over 10 years

FIGURE 2.4.2

Long Term Trend for NO_2



Note: 15 Sites operated over 20 years

2.4.4 Ontario AAQC

0.20 ppm (1-hour)
0.10 ppm (24-hour)

2.4.5 Method of Monitoring

Monitoring for oxides of nitrogen compounds is based on the principle of chemiluminescence involving a gas phase reaction of NO with ozone. For NO_2, the sample stream is passed throughout a catalytic converter where NO_2 is reduced to NO.

2.4.6 Locations of Monitors

Appendix C provides a description of the provincial NO_2 network. NO_2 monitoring was carried out at 32 locations in 1994.

2.4.7 Monitoring Results

The distribution by percentile of the hourly data, the annual average, and the maximum one-hour and 24-hour values are provided in Appendix C. Also given are the number of exceedances of the NO_2 AAQC. The lowest level (0.004 ppm annual mean) measured in the province was recorded at Simcoe (22071). The highest annual mean (0.037 ppm) was measured in Toronto at the Mission site (31049), while the maximum 1-hour value (0.18 ppm) was recorded at Windsor (12008).

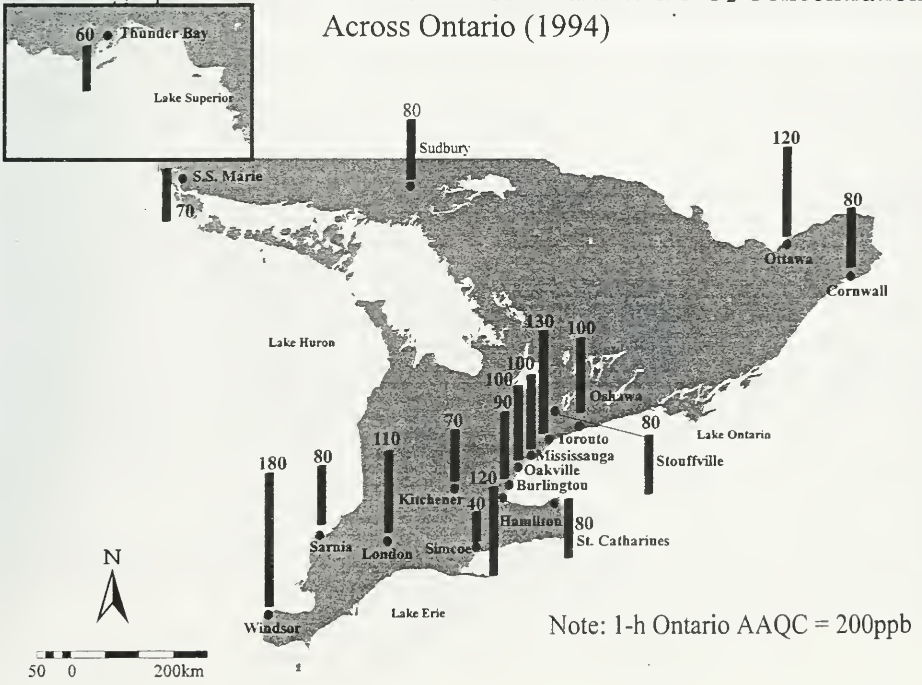
During 1994, there were no exceedances of the 1-hour AAQC (0.20 ppm) or the 24-hour (0.10 ppm).

2.4.8 Trends in NO_2

The ten year trend of the annual mean concentrations of NO_2 for selected sites in Ontario are summarized in Table 2.4.1 and presented graphically in Figure 2.4.1. From 1985 to 1989 there was little change. After 1989 there has been a declining trend (approximately 20 per cent decrease between 1989 and 1994). However, there has been a 5 per cent increase in 1994 over the 1993 level. The long term trend Figure 2.4.2 shows a 33 per cent decline between 1977 and 1994. The geographical distribution of the 1-hour maximum NO_2 concentrations across the province shows as one would expect, that the highest levels are recorded primarily in the large urban centres (Figure 2.4.3). This is because vehicles are the major source for this pollutant.

FIGURE 2.4.3

Geographical Distribution of 1-Hour Maximum NO2 Concentrations Across Ontario (1994)



Note: 1-h Ontario AAQC = 200ppb

Table 2.4.1
10-YEAR TREND FOR NO_2
Annual Mean (ppm

City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CORNWALL	0.010	0.011	0.010	0.008	0.009	0.008	0.006	0.010	0.008	0.009
ETOBICOKE	0.026	0.027	0.028	0.021	0.030	0.026	0.025	0.026	0.026	0.027
HAMILTON	0.025	0.027	0.026	0.024	0.026	0.022	0.022	0.019	0.022	0.022
KITCHENERx	0.029	0.032	0.026	0.027	0.025	n/a	0.013	0.015	0.014	0.014
LONDON	0.025	0.026	0.021	0.020	0.022	0.021	0.019	0.018	0.020	0.023
MISSISSAUGA	0.026	0.026	0.025	0.021	0.025	0.020	0.022	0.023	0.020	0.022
NORTH YORK*	0.027	0.023	0.025	0.027	0.028	0.028	0.029	0.024	0.021	0.020
OAKVILLE	0.016	0.020	0.017	0.016	0.016	0.017	0.017	0.016	0.019	0.017
OSHAWA	0.020	0.021	0.022	0.024	0.024	0.019	0.018	0.018	0.019	0.018
OTTAWA	0.012	0.012	0.015	0.016	0.017	0.016	0.020	0.017	0.019	0.019
SARNIA	0.019	0.021	0.012	0.015	0.019	0.021	0.019	0.020	0.016	0.018
SCARBOROUGH	0.018	0.022	0.022	0.025	0.027	0.025	0.024	0.019	0.019	0.022
SIMCOE	0.006	0.005	0.005	0.008	0.010	0.005	0.007	0.010	0.008	0.004
ST CATHARINES	0.017	0.019	n/a	0.018	0.021	0.016	0.016	0.012	0.017	0.017
SUDBURY	0.007	0.010	0.011	0.010	0.011	0.009	0.009	0.009	0.010	0.011
TORONTO	0.026	0.027	0.025	0.025	0.027	0.025	0.029	0.027	0.029	0.030
WINDSOR	0.026	0.025	0.027	0.030	0.027	0.025	0.025	0.025	0.026	0.028
COMPOSITE MEAN	**0.020**	**0.021**	**0.020**	**0.020**	**0.021**	**0.019**	**0.019**	**0.018**	**0.018**	**0.019**

*** Site changed location from Science Centre (34002) to North York Central (34020) in 1992.**

x Site changed location from Edna/Frederick St (26029) to West Ave/Homewood (26060) in 1990.

n/a - data not available

2.5 NITRIC OXIDE (NO)

2.5.1 Characteristics

NO is a colourless and odourless gas which oxidizes to NO_2 in the presence of hydrocarbons and sunlight.

2.5.2 Sources

Same as for NO_2.

2.5.3 Effects

There are no known direct effects on health or vegetation at ambient levels.

2.5.4 Ontario AAQC

None

2.5.5 Method of Monitoring

Same as for NO_2.

2.5.6 Locations of Monitoring

Same as for NO_2.

2.5.7 Monitoring Results

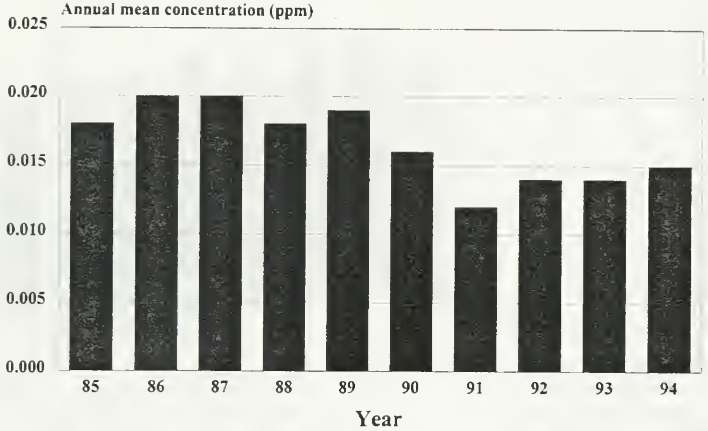
Simcoe (22071), a rural location in west-central Ontario, recorded the lowest annual means (0.001 ppm) while the Mission site (31049) in Toronto recorded the highest (0.052 ppm).

2.5.8 Trends in NO

The ten year trend data for NO are summarized in Table 2.5.1 and are presented graphically in Figure 2.5.1. From 1985 to 1989 there was an overall slight increase. After 1989 there has been a decreasing trend with a minimum value being recorded in 1991. Since 1991 NO annual means have been increasing with 1994 levels approximately 25 per cent higher than the 1991 mean. However, the annual means after 1989 are all smaller than the means recorded between 1985 and 1989.

FIGURE 2.5.1

10-Year Trend for NO



Note: 17 Sites operated over 10 years

10-YEAR TREND FOR NO

Annual Mean (ppm)

City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CORNWALL	0.008	0.005	0.011	0.010	0.009	0.008	0.006	0.008	0.007	0.006
ETOBICOKE	0.027	0.031	0.028	0.026	0.029	0.023	0.019	0.025	0.022	0.023
HAMILTON	0.019	0.022	0.014	0.017	0.014	0.012	0.011	0.015	0.017	0.018
KITCHENERx	0.047	0.051	0.051	0.047	0.045	n/a	0.005	0.006	0.006	0.008
LONDON	0.013	0.019	0.018	0.015	0.015	0.016	0.011	0.013	0.013	0.018
MISSISSAUGA	0.030	0.032	0.030	0.026	0.024	0.019	0.020	0.022	0.024	0.026
NORTH YORK*	0.028	0.022	0.026	0.021	0.026	0.038	0.020	0.021	0.016	0.017
OAKVILLE	0.016	0.020	0.018	0.036	0.030	0.015	0.011	0.013	0.016	0.015
OSHAWA	0.017	0.016	0.019	0.014	0.018	0.020	0.014	0.014	0.017	0.019
OTTAWA	0.011	0.010	0.012	0.011	0.012	0.009	0.009	0.011	0.012	0.011
SARNIA	0.007	0.009	0.006	0.006	0.007	0.007	0.006	0.007	0.007	0.009
SCARBOROUGH	0.032	0.032	0.035	0.033	0.033	0.027	0.026	0.025	0.024	0.026
SIMCOE	0.004	0.007	0.005	0.002	0.001	0.001	0.002	0.002	0.001	0.001
ST CATHARINES	0.009	0.008	n/a	0.010	0.011	0.011	0.008	0.014	0.012	0.010
SUDBURY	0.010	0.008	0.008	0.005	0.006	0.005	0.005	0.004	0.004	0.005
TORONTO	0.019	0.022	0.021	0.018	0.022	0.021	n/a	0.025	0.027	0.025
WINDSOR	0.015	0.021	0.014	0.014	0.015	0.016	0.019	0.018	0.017	0.017
COMPOSITE MEAN	**0.018**	**0.020**	**0.020**	**0.018**	**0.019**	**0.016**	**0.012**	**0.014**	**0.014**	**0.015**

* Site changed location from Science Centre (34002) to North York Central (34020) in 1992.

x Site changed location from Edna/Frederick St (26029) to West Ave/Homewood (26060) in 1990.

n/a - data not available

2.6 NITROGEN OXIDES (NO_x)

2.6.1 Definition

NO_x is assumed to be the sum of NO_2 and NO concentrations in the atmosphere (typically expressed in parts per million).

2.6.2 Sources

Same as for NO_2.

2.6.3 Effects

NO_x contributes to haze and visibility reduction and is also known to cause deterioration and fading of certain fabrics and damage to vegetation. Depending on concentration and extent of exposure, plants may suffer leaf lesions and reduced crop yield. Sensitivity of plants to nitrogen oxides depends on a variety of factors including species, time of day, amount of light, stage of maturity and the presence or absence of other air pollutants such as SO_2 and ozone.

2.6.4 Ontario AAQC

None

2.6.5 Method of Monitoring

Same as for NO_2.

2.6.6 Locations of Monitoring

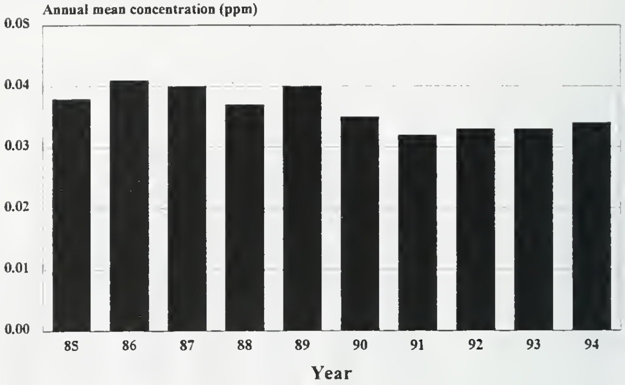
Same as for NO_2.

2.6.7 Monitoring Results

Simcoe (22071), a rural location in west-central Ontario, recorded the lowest annual means (0.006 ppm). The highest annual mean (0.088 ppm) was recorded at the Mission site (31049) in downtown Toronto.

FIGURE 2.6.1

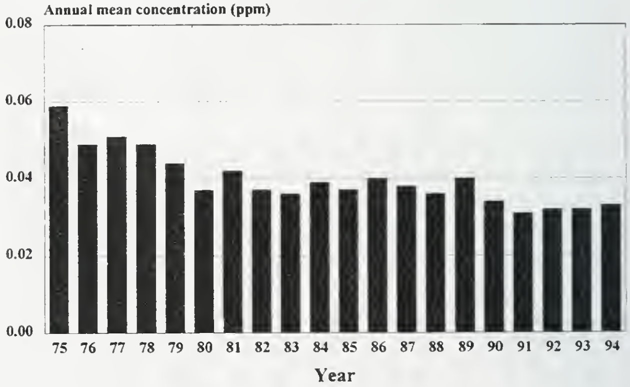
10-Year Trend for NOx



Note: 17 Sites operated over 10 years

FIGURE 2.6.2

Long Term Trend for NOx



Note: 15 Sites operated over 20years

FIGURE 2.6.3

Ontario Nitrogen Oxides Emissions by Sectors

(Emissions From Human Activity, Early 1990s)

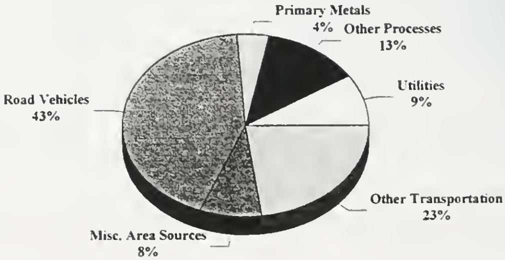
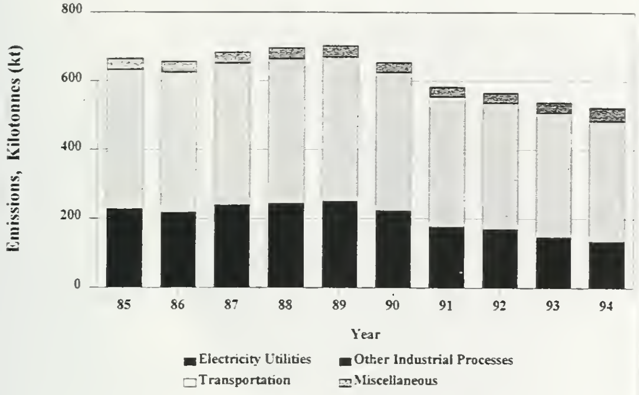


FIGURE 2.6.4

Ontario Nitrogen Oxides Emission Trend (1985 to 1994)



2.6.8 Trends in NO_x

Data for the period 1985 to 1994 are displayed in Table 2.6.1 and Figure 2.6.1. The trend is similar to the NO trend since NO is approximately 90 to 95 per cent of NO_x emitted by vehicles. The long term annual means (1975-1994) of NO_x recorded at sites across Ontario show a 40 per cent decrease in ambient levels over the period (Figure 2.6.2).

The predominant sources of NO_x in Ontario are from the transportation sector which accounts for approximately 66 per cent (see Figure 2.6.3). The emission trend of NO_x shows a gradual increase from 1985 to 1989 and a slight overall decrease from 1990 onwards. The decreasing trend is largely due to emission decrease from the transportation sector (Figure 2.6.4), and economic slowdown.

Table 2.6.1
10-YEAR TREND FOR NO_X
Annual Mean (ppm)

City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CORNWALL	0.018	0.016	0.021	0.017	0.019	0.018	0.016	0.019	0.017	0.017
ETOBICOKE	0.053	0.059	0.057	0.046	0.061	0.050	0.044	0.051	0.049	0.049
HAMILTON	0.044	0.049	0.039	0.041	0.040	0.035	0.033	0.033	0.039	0.040
KITCHENERx	0.076	0.083	0.075	0.073	0.070	0.039	0.021	0.022	0.021	0.023
LONDON	0.038	0.044	0.038	0.035	0.037	0.034	0.031	0.034	0.035	0.038
MISSISSAUGA	0.055	0.059	0.054	0.047	0.048	0.039	0.042	0.042	0.046	0.050
NORTH YORK*	0.055	0.046	0.050	0.049	0.054	0.066	0.049	0.045	0.037	0.038
OAKVILLE	0.032	0.040	0.035	0.036	0.042	0.031	0.028	0.030	0.035	0.034
OSHAWA	0.038	0.038	0.042	0.036	0.042	0.040	0.032	0.033	0.036	0.037
OTTAWA	0.024	0.023	0.028	0.026	0.029	0.025	0.029	0.028	0.029	0.028
SARNIA	0.027	0.030	0.019	0.021	0.028	0.029	0.026	0.026	0.023	0.028
SCARBOROUGH	0.050	0.055	0.057	0.058	0.060	0.051	0.050	0.046	0.046	0.050
SIMCOE	0.010	0.012	0.010	0.010	0.012	0.007	0.009	0.013	0.010	0.006
ST CATHARINES	0.026	0.027	n/a	0.029	0.033	0.027	0.024	0.027	0.030	0.028
SUDBURY	0.016	0.018	0.019	0.015	0.016	0.014	0.014	0.014	0.016	0.017
TORONTO	0.044	0.048	0.047	0.044	0.048	0.046	0.054	0.052	0.055	0.054
WINDSOR	0.041	0.046	0.041	0.044	0.042	0.041	0.042	0.042	0.042	0.042
COMPOSITE MEAN	**0.038**	**0.041**	**0.040**	**0.037**	**0.040**	**0.035**	**0.032**	**0.033**	**0.033**	**0.034**

* Site changed location from Science Centre (34002) to North York Central (34020) in 1992.

x Site changed location from Edna/Frederick St (26029) to West Ave/Homewood (26060) in 1990.

n/a - data not available

2.7 CARBON MONOXIDE (CO)

2.7.1 Characteristics

Carbon monoxide is a colourless, odourless, tasteless and poisonous gas which is produced as a result of incomplete combustion of fossil fuels. It is of concern as an air pollutant because it has a strong affinity for haemoglobin and thus reduces the ability of blood to transport oxygen.

2.7.2 Sources

The transportation sector is the primary source of CO emissions (67 per cent) and includes road vehicles, air, rail, and marine activities in Ontario. A secondary source is primary metal processing (21 per cent). The remaining CO emissions are from fuel combustion in space heating and other industrial processes (Figure 2.7.1).

2.7.3 Effects

1 hour average

less than 30 ppm- no known effects
30 ppm- increased cardiovascular symptoms for smokers with heart disease
50 ppm- increased cardiovascular symptoms for non-smokers with heart disease. Some visual impairment.

The health threat is most serious for those who suffer from cardiovascular disease. Healthy individuals are also affected but only at higher concentrations. Exposure to elevated levels is associated with impairment of visual perception, learning ability, manual dexterity and performance of complex tasks.

FIGURE 2.7.1

Ontario Carbon Monoxide Emissions by Sectors
(Emissions From Human Activity, Early 1990s)

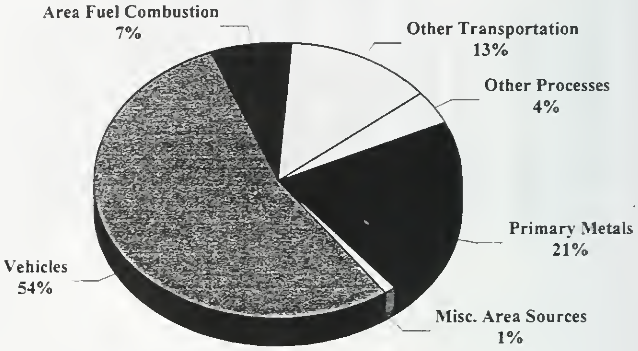
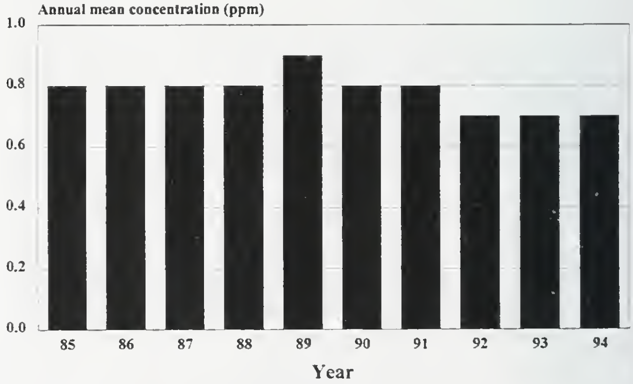


FIGURE 2.7.2

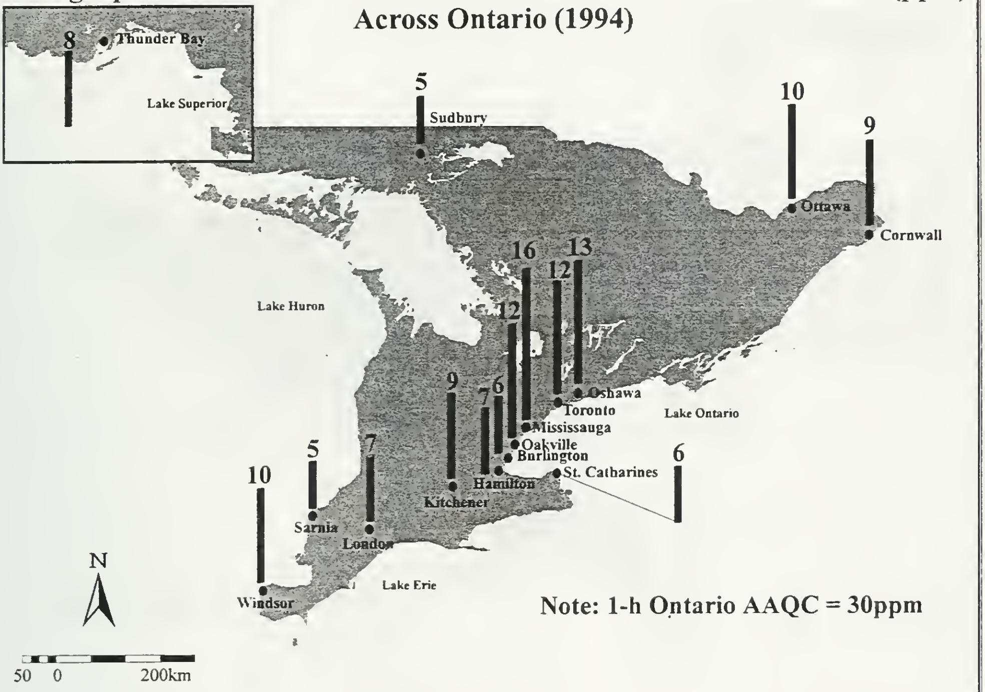
10-Year Trend for CO



Note: 16 Sites operated over 10 years

FIGURE 2.7.3

Geographical Distribution of 1-Hour Maximum CO Concentrations (ppm) Across Ontario (1994)



2.7.4 Ontario AAQC

30 ppm (1-hour)
13 ppm (8-hours)

2.7.5 Method of Monitoring

Non-dispersive infrared photometry based on the preferential absorption of infrared radiation by CO is the method used.

2.7.6 Locations of Monitors

Appendix C provides a description of the provincial CO network. CO was monitored at 24 stations in 1994.

2.7.7 Monitoring Results

The distribution by percentile of the hourly data, the mean, and the maximum one-hour and eight-hour values measured during 1994 are given in Appendix C.

The lowest annual average (0.1 ppm) was measured at Sudbury (77203) while the highest annual average (1.7 ppm) was recorded at the Mission site (31049) in Toronto. This monitor is located in the Yonge Street corridor exposing it to motor vehicle exhaust. The highest measured one-hour value (16 ppm) was measured at the Mississauga site (46110) and the highest eight-hour value (8 ppm) was measured at the York site (36030).

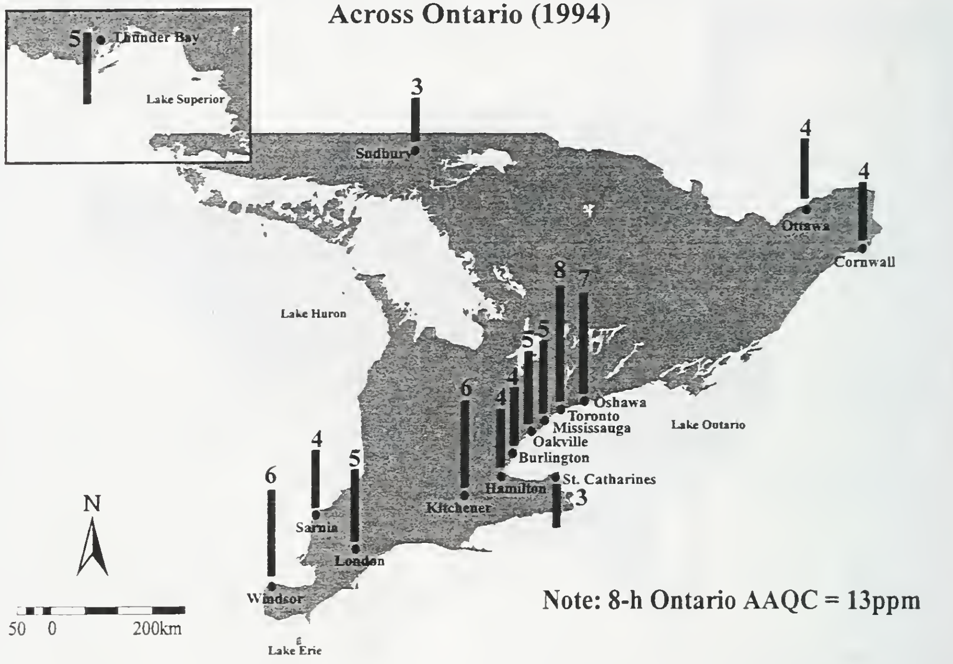
There were no exceedances of the Ontario one-hour (30 ppm) criterion or the eight-hour criterion (13 ppm) during 1994 (See Table 2.1).

2.7.8 Trends in CO

The trend in mean annual CO concentrations at locations which possess a 10-year record is shown in Table 2.7.1 and is summarized for the province in Figure 2.7.2. From 1985 to 1994 mean ambient CO levels have decreased by 12 per cent over the 10-year period. The geographical distribution of the 1-hour maximum and 8-hour maximum ambient CO

FIGURE 2.7.4

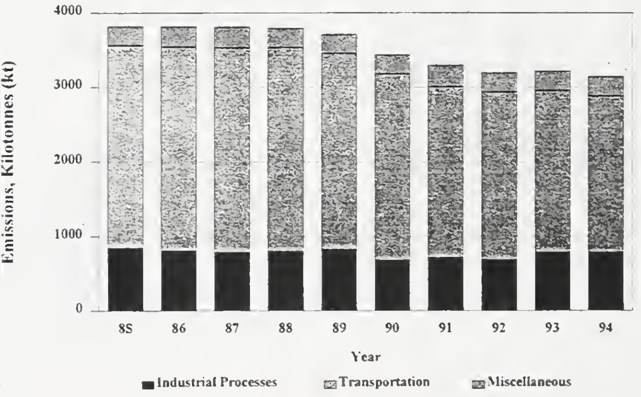
Geographical Distribution of 8-Hour Maximum CO Concentrations (ppm) Across Ontario (1994)



Note: 8-h Ontario AAQC = 13ppm

FIGURE 2.7.5

Ontario Carbon Monoxide Emission Trend (1985 to 1994)



concentrations are displayed in Figures 2.7.3 and 2.7.4, respectively. The Mississauga monitoring site recorded the highest level for the 1-hour averaging period. The York site recorded the highest concentration for the 8-hour averaging period. This is directly related to vehicle emissions of CO.

The transportation sector accounts for about 67 per cent of the total CO emissions. The emission trend (Figure 2.7.5) shows a steady decrease in CO emissions since 1989 due to the new vehicle emission standards. Despite gradual annual increases in total vehicle kilometres travelled (Figure 2.7.6), emissions from the transportation sector have decreased by about 20 per cent since 1985. The long term trend for CO (1971-1994), shown in Figure 2.7.7, indicates substantial reduction in annual mean concentration since the early 1970s, approximately 80 per cent over the period.

2.8 TOTAL HYDROCARBONS (THC)

2.8.1 Characteristics

Hydrocarbon compounds contain primarily methane (colourless, odourless) which is present at about 1.5 ppm in the ambient atmosphere. Non-methane hydrocarbons (or reactive hydrocarbons) are usually present at much lower levels. This fraction reacts readily with nitrogen oxides and other oxidants in the presence of sunlight to form ozone.

2.8.2 Sources

Anthropogenic sources include motor vehicles, gasoline storage tanks, petroleum and chemical industries, solvent uses, landfill sites, paint manufacturing, application and fermentation sites.

Natural sources include trees and other vegetation and decay of animal and plant material.

2.8.3 Effects

Effects depend on the individual chemical compound, which the analytical technique cannot identify.

2.8.4 Ontario AAQC

There is no Ontario AAQC for THC. However, criteria and standards exist for specific hydrocarbons and other organics.

FIGURE 2.7.6

Ontario Vehicle-Kilometres Travelled

(1985 to 1994)

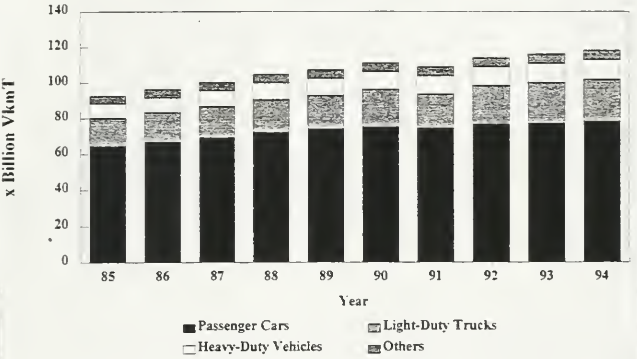
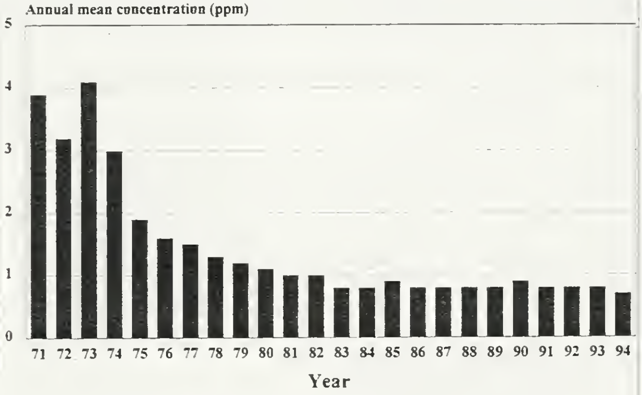


FIGURE 2.7.7

Long Term Trend for CO



Note: 9 Sites operated over 24 years

2.8.5 Method of Monitoring

A calibrated flame ionization detector is used.

2.8.6 Locations of Monitors

Appendix C provides a description of the provincial THC network. THC was monitored at 5 locations in 1994.

2.8.7 Monitoring Results

The distribution by percentile of the hourly data, the mean, and the maximum one-hour and 24-hour

Table 2.7.1
10-YEAR TREND FOR CO
Annual Mean (ppm)

CITY	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CORNWALL	0.20	0.20	0.30	0.60	0.80	0.60	0.80	0.50	0.80	0.50
ETOBICOKE	1.30	1.20	1.20	1.20	0.70	0.80	0.80	0.60	0.70	0.70
HAMILTON	1.20	1.10	1.20	1.20	1.20	1.20	1.10	1.20	1.10	0.80
KITCHENER	0.80	0.90	0.80	0.90	1.10	n/a	0.60	0.50	0.40	0.30
LONDON	0.30	0.30	0.40	0.50	0.90	0.60	0.70	0.70	0.60	0.50
MISSISSAUGA	1.90	1.40	1.30	1.00	1.10	1.10	1.10	1.10	0.90	0.80
NORTH YORK*	1.40	1.30	1.20	0.80	0.80	1.00	0.70	1.00	1.10	0.90
OAKVILLE	1.00	1.00	0.80	0.90	0.90	0.50	0.50	0.30	0.70	0.70
OSHAWA	1.00	1.20	0.80	1.10	0.90	0.90	0.80	0.90	0.90	1.00
OTTAWA	0.60	0.60	0.30	0.50	0.70	0.70	1.00	1.10	0.90	0.80
SARNIA	0.20	0.20	0.20	0.30	0.30	0.30	0.20	0.30	0.20	0.20
SCARBOROUGH	n/a	1.30	1.00	1.10	1.00	1.20	1.20	1.00	0.80	1.00
ST CATHARINES	n/a	0.20	0.20	n/a	1.00	0.90	1.00	0.70	0.50	0.40
SUDBURY	0.10	0.10	0.10	0.30	0.40	0.50	0.30	0.10	0.10	0.10
TORONTO	1.10	1.00	1.10	0.60	0.90	1.10	1.10	1.00	1.10	1.00
WINDSOR	0.50	0.50	0.70	0.90	1.00	1.20	1.00	0.90	0.80	1.00
COMPOSITE MEAN	**0.80**	**0.80**	**0.80**	**0.80**	**0.90**	**0.80**	**0.80**	**0.70**	**0.70**	**0.70**

*** Site changed location from Science Centre (34002) to North York Central (34020) in 1992.**

n/a - data not available

values are given in Appendix C.

The locations and values for the lowest, and highest means are given in Table 2.1. The highest 1-hour THC value (11.0 ppm) for the year was measured at the Oakville monitor (44015).

2.9 TOTAL SUSPENDED PARTICULATES (TSP), INHALABLE PARTICULATE (PM_{10}) and SUSPENDED PARTICLES (SP)

2.9.1 Characteristics

Total suspended particulates is a generic term for airborne particles including smoke, fume, dust, fly ash and pollen. Composition varies with place and season but normally includes soil particulates, organic matter, sulphur and nitrogen compounds and metals such as lead, carbon or higher hydrocarbons formed by incomplete combustion of hydrocarbon fuels. Size range for TSP varies from 0.1 to 100 microns (µm).

An appreciable amount, up to 60 per cent, of total suspended particulate matter may consist of PM_{10} which is composed of both primary (coarse particles in the range 10.0 to 2.6 microns) and fine particles less than 2.5 µm ($PM_{2.5}$) which includes sulphates and sulphuric acid aerosols.

Suspended particles (SP) is defined as a relative measure of suspended particulate matter in the atmosphere most likely to reach the lungs (diameter generally less than 10 µm). It is used as a real time estimate of PM_{10} concentrations for use in the calculation of the Air Pollution Index and monitoring of fine particulates. SP is determined by the amount of light transmission due to the trapping of particles on a filter medium and is expressed as coefficient of haze (COH). Suspended particles range in size from 0.1 to 25 µm in diameter.

2.9.2 Sources

Particulate matter is emitted from industrial processes which include fuel combustion, incineration, construction, mining, metal smelting and processing. Particulate emissions from these processes have been effectively controlled with proper emission control devices. In the urban airshed, motor vehicle exhaust, residential wood combustion and road dust are the major sources of particulate emissions (Figure 2.9.1).

Natural sources of particulate matter include wind-blown soil, forest fires, ocean spray and volcanic activities.

Fuel combustion for transportation, space heating and industrial processes account for the majority of the provincial anthropogenic particulate emissions (excluding natural sources). The emissions from natural sources vary randomly every year and can be a much larger contributor than the direct industrial or combustion emitters of particulate matter.

2.9.3 Health Effects

Inclusion of total suspended particulate matter (TSP) among the original criteria pollutants in the early 1970s is clear evidence of their potential to adversely affect human health. Research conducted during the past two decades has generally served to corroborate these early concerns. There is a wide variety of observed health effects with inhalation of suspended particulates. These include: increased incidence of respiratory symptoms, decreased pulmonary function, increased hospitalizations and other health care visits for cardiopulmonary disease, increased cardiopulmonary disease mortality as well as restrictions in activity such as days of work loss and school absenteeism. Recent work has yielded three important findings:

- deleterious effects are evident at ambient levels that are below the current Canadian, U.S., and W.H.O. guidelines/standards;

- threshold concentrations below which there are no health effects observed have not been clearly identified;

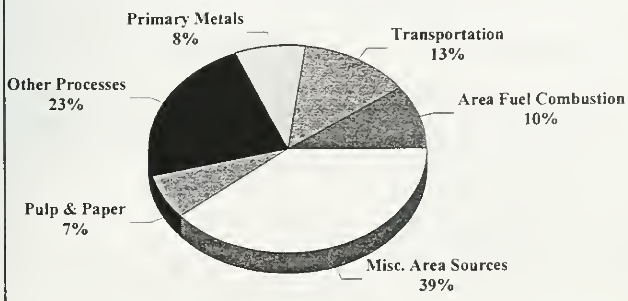
- smaller particles (e.g., PM_{10}), which can be inhaled further into the respiratory tract, are more likely to be associated with health effects.

PM_{10} has been determined to be the particle size which is most likely to be inhaled and deposited into the thoracic region of the lung. Particulate mass in the fine particulate mode is composed mainly of sulphates, nitrates, ammonium, elemental carbon and other condensed organic matter. In southern Ontario, sulphate and its associated cations, e.g., ammonium, have been found to be the predominant species in the fine particulate mode and at times contributes up to 50 per cent of the total fine particulate matter. More serious health effects may be associated with suspended particulate matter which contains a toxic particulate component or which has adsorbed a gaseous pollutant on the surface of the particles..

FIGURE 2.9.1

Ontario Particulate Emissions by Major Sectors

(Emissions From Human Activity, Early 1990s)



Note: Emissions from roads, construction, farming etc. are not included.

In the upper respiratory tract, particles greater than 5.0 µm in diameter are filtered from inhaled air. Hairs in the nasal passage are the first line of defence. Particles may also be trapped in the mucus which lines the nasal cavity and trachea. Particles less than 5.0 µm can reach the alveoli (the gas exchange region of the lungs) and remain there for long periods of time. Toxic substances adhering to these particles can thus affect this sensitive region of the lungs.

2.9.4 Effects on Vegetation

Vegetation may be adversely affected by excessive quantities of airborne particles. Particles cover leaves and plug stomata, thereby reducing the amount of radiation reaching the interior of the leaf and also reducing the amount of carbon dioxide entering the leaf, thus suppressing the growth and yield of some plants. Specific particles such as fluorides cause additional damage.

2.9.5 Effects on Materials

Particles soil fabrics, painted surfaces and buildings. This adds to cleaning and replacement costs by reducing the life of materials and finishes. The extent and type of damage depend on the chemical composition and physical state of the particulate. Passive damage is caused when particles settle on and soil materials, creating a need for more frequent cleaning. The cleaning process weakens the material and thus reduces the life-time of the material. Particles emitted from diesel exhausts are particularly effective in soiling as they have a high optical absorbance (blackness) and an oily nature.

Chemical damage results when the particulates themselves are corrosive, or when they carry absorbed corrosive substances with them. Particulates accelerate corrosion especially in the presence of sulphur-containing compounds. Since particulates serve as condensation nuclei on which moisture can condense, gases adhering to the surface of particulates dissolve in the water formed and thus, the corrosion rates of materials increase significantly in areas of high humidity. Corrosion rates of various metals are highest in urban and industrial areas.

2.9.6 Atmospheric Effects

Fine particles can be sensed by the naked eye in the form of haze and reduced visibility. Reduction in visibility is caused by the absorption and scattering of sunlight by fine particles and aerosols. The amount of moisture in the atmosphere also plays an important part in the formation of haze, as water vapour condenses on sulphates and fine particles at humidities as low as 70 per cent. Dry haze, that is haze due to fine particles alone in the atmosphere, is formed at relative humidities below 70 per cent.

When relative humidities are below 70 per cent scattering of light by solid particles in the range from 0.1 to 1.0 µm takes place. Particles in this size range are principally formed from chemical conversion of gases (aerosols). Ammonium sulphates and nitrates are two of these aerosols. Ammonium is a by-product of the nitrogen cycle, while sulphates and nitrates arise from combustion processes. Sulphates are smaller than nitrates and therefore play a major role in visibility reduction.

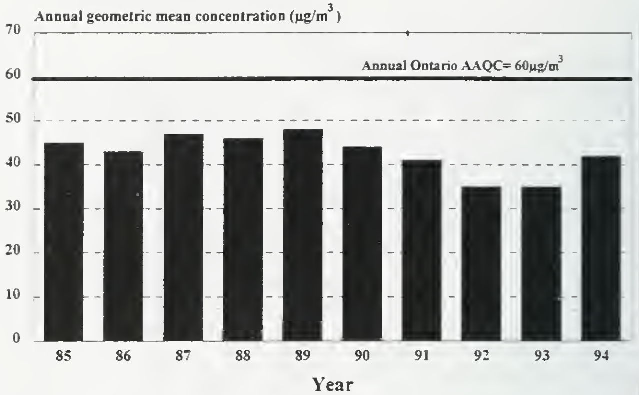
2.9.7 TOTAL SUSPENDED PARTICULATE (TSP)

Ontario AAQC

120 µg/m³ (24-hours)
60 µg/m³ (1- year - geometric mean)

FIGURE 2.9.2

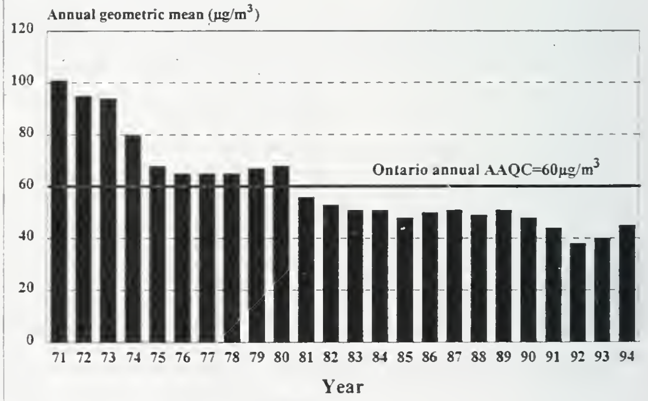
10-Year Trend for TSP



Note: 16 Sites operated over 10 years

FIGURE 2.9.3

Long Term Trend for TSP



Note: 9 Sites operated over 24 years

Method of Monitoring

TSP is measured by an instrument called a Hi-vol sampler. Air is drawn through a filter at the rate of approximately 1.4 cubic metres per minute (m³/min). The (daily) mass concentration of total suspended particulate matter is computed gravimetrically from the mass of collected particles and the volume of air sampled.

Location of Monitoring

Appendix C provides a description of the provincial TSP monitoring network for 1994. TSP was measured at 99 locations in 1994.

Monitoring Results

The lowest TSP level measured in the province was at Dorset (49010)

Table 2.9.1
10-YEAR TREND FOR TSP
Annual Geometric Mean ($\mu g/m^3$)

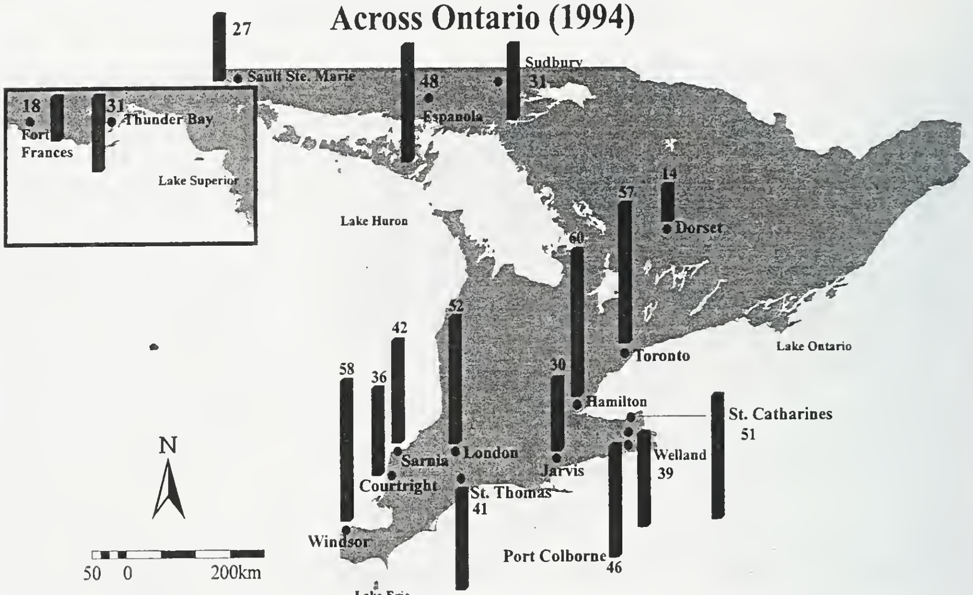
City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
COURTRIGHT	34	36	34	34	36	30	26	28	26	36
ESPANOLA	42	37	40	37	50	44	45	38	38	48
FORT FRANCES	26	29	29	26	29	28	25	20	15	18
HAMILTON***	71	76	77	68	75	64	61	59	53	60
JARVIS	49	44	43	43	52	34	41	30	25	30
LONDON	42	50	65	54	57	52	52	43	42	52
PORT COLBORNE	49	54	45	46	51	50	47	41	37	46
S.S.MARIE	36	34	35	35	33	35	32	27	27	27
SARNIA	46	45	42	42	37	34	34	31	33	42
ST CATHARINES	50	60	47	46	55	45	43	40	46	51
ST THOMAS	56	51	65	54	45	38	34	32	31	41
SUDBURY	31	32	35	30	41	42	34	29	31	31
THUNDER BAY**	36	40	35	37	36	32	33	30	30	31
TORONTO	50	51	52	58	60	60	51	43	48	57
WELLAND	48	42	48	51	48	48	49	35	38	39
WINDSOR	59	63	68	62	61	60	51	41	49	58
COMPOSITE MEAN	**45**	**43**	**47**	**46**	**48**	**44**	**41**	**35**	**35**	**42**

** Changed location from Archibald/Arthur St. (63005) to 615 James St. S (63200) in 1986.

*** Changed location from Barton/Sanford (29025) to Elgin/Kelly St. (29000) in 1988.

FIGURE 2.9.4

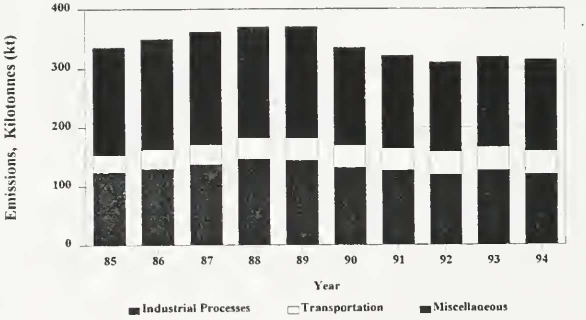
Geographical Distribution of Annual Mean TSP Concentrations Across Ontario (1994)



Note: Annual Ontario Geometric AAQC = 60µg/m³

FIGURE 2.9.5

Ontario Particulate Emission Trend (1985 to 1994)



where the annual geometric mean was 14 µg/m³.

The highest annual geometric mean (100 µg/m³) was recorded at the Howard Avenue monitor in Windsor. The greatest percentage of exceedances (28) of the 24-hour criterion was recorded in Hearst while the maximum 24 h concentration (420 µg/m³) was recorded in Wawa.

There was a total of 47 stations (47 per cent) which exceeded the 24-hour criterion and 15 (15 per cent) which exceeded the one-year criterion.

Trends

The trend in annual mean TSP concentrations at 16 sites which have a 10-year record is shown in Figure 2.9.2 and summarized for the province in Table 2.9.1. Particulate levels over the 10-year period (1985 to 1994) show no significant trend. There was a decreasing trend from

TABLE 2.9.2 COMPARISON OF INHALABLE PARTICULATE (IP) VERSUS TOTAL SUSPENDED PARTICULATE (TSP) 1994

CITY	STATION LOCATION	N	MEAN IP	MEAN TSP	MAX IP	MAX TSP	% IP of TSP
WINDSOR	WRIGHT/WATER	40	31	65	79	143	48
WINDSOR	3665 WYANDOTTE ST. EAST	43	32	73	95	234	43
WINDSOR	467 UNIVERSITY AVENUE	47	27	58	91	144	47
LONDON	801 COMMISSIONERS	39	17	34	52	95	50
NANTICOKE	WLPOLE P.S.	43	16	35	41	86	46
THOROLD	185 QUEEN ST.S	41	31	68	79	191	46
HAMILTON	BUCHANAN P.S.	32	21	37	39	83	57
HAMILTON	ELGIN/KELLY	45	27	59	96	204	46
HAMILTON	BEACH BLVD.	50	25	64	65	183	39
HAMILTON	GERTRUDE/DEPEW	50	34	73	90	157	47
TORONTO	BAY/GROSVENOR 50	50	24	58	75	137	41
ST. CATHARINES	71 KING STREET	38	24	54	49	104	44
THUNDER BAY	615 JAMES ST. SOUTH	47	17	30	38	70	57
S.S. MARIE	BONNEY STREET	45	37	73	95	213	51
S.S. MARIE	WM. MERRIFIELD P.S.	50	19	35	57	107	54
FORT FRANCES	250 CHURCH STREET	45	17	38	45	155	45
SUDBURY	19 LISGAR STREET	48	21	31	44	77	68

N = Number of data points, a data point is a simultaneous measurement of IP and TSP

IP is measured by PM10 sampler

Units are in μg/m^3

Mean - Geometric mean

1989 to 1993 and the annual mean in 1994 shows an increase of 20 per cent above the 1993 levels. In 1994 annual mean levels have increased at the majority of TSP monitoring sites when compared to levels in 1993. Over the long term 1971-1994, annual mean concentrations, as determined by the 9 sites which operated over the 24-year period, show a 58 per cent decline (Figure 2.9.3). The spatial distribution of annual TSP levels is shown in Figure 2.9.4 for monitoring sites across Ontario.

Particulate emissions from selected major sectors including transportation, utilities, and major industrial processes showed a slight upward trend from 1985 to 1989 and a slight downward trend since 1990 (Figure 2.9.5). Contributions from fugitive sources such as road dust, construction and surface erosion are not included in the annual emissions. Since particulate emissions from forest fires can vary from year to year and can be several times the emissions from human activity, they are not included in the emission trend.

2.9.8 INHALABLE PARTICULATE (IP/PM$_{10}$)

Ontario AAQC

Ontario presently does not have a criterion for PM$_{10}$

Method of Monitoring

IP is monitored by a modified Hi-vol sampler outfitted with a size selective inlet to restrict particle size to less than 10µm. The daily mass of the inhalable particulate matter is computed from the mass of the collected particles and the volume of air sampled. Quartz fibre filters are used as the filter medium for collection.

Location of Monitoring

PM$_{10}$ monitoring sites are shown in Appendix C. During 1994, PM$_{10}$ was measured at 19 locations.

Monitoring Results

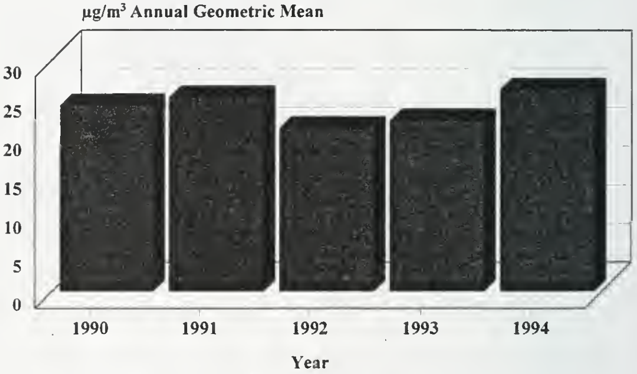
The distribution of inhalable particulate measured at sites across Ontario during 1994 by percentile, the maximum 24-hour value and the geometric mean is given in Appendix C.

The highest annual geometric mean (36 µg/m^3) was recorded at Bonney Street in Sault Ste Marie while the maximum 24-hour concentration (96 µg/m^3) was recorded in Hamilton.

A comparison of inhalable particulate versus TSP was done for all available data collected during 1994. Table 2.9.2 summarizes the data as to the number of samples, the mean and maximum recorded values of IP and TSP and the percentage IP

FIGURE 2.9.6

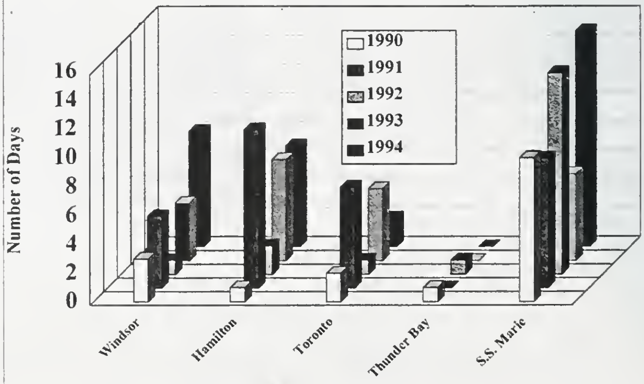
5-Year Trend in PM$_{10}$ at Selected Sites Across Ontario (1990 - 1994)



Note: 5 Sites used in Average.

FIGURE 2.9.7

Number of Days PM$_{10}$ > 50 µg/m^3 Across Ontario (1990 - 1994)



Note: California Daily Standard is 50 µg/m^3.

of the TSP loading. IP varies from 39 per cent of the TSP loading at the Hamilton Beach Blvd site to 68 per cent of the total loading at the Lisgar St. monitor in Sudbury.

Trends

Annual mean PM_{10} concentrations for the five sites that monitored PM_{10} during the period 1990 to 1994 show that levels decreased during 1992 and 1993, then increased in 1994 (Figure 2.9.6). The 1994 annual mean concentration is approximately 18 per cent higher than in 1993 and is the highest annual mean recorded during the five year period. The PM_{10} trend is similar to that of the TSP levels over the last five years.

Ontario presently does not have a criterion for PM_{10}; however, a joint Federal/Provincial Air Quality Committee is in the process of developing a standard/criterion based on health effects. In this report, the California 24-hour standard of 50 µg/m³ has been used to compute the number of days during each year that the standard was exceeded. Figure 2.9.7 shows the number of days that the California standard was exceeded at the five sites during the years 1990 to 1994. The highest number of exceedance days was recorded at Sault Ste Marie and the lowest at Thunder Bay.

2.9.9 SUSPENDED PARTICLES (SP)

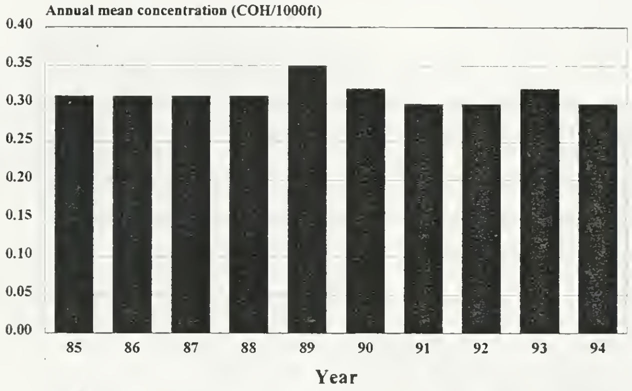
Effects

1 hour average

<2.0 COH units - no known effects
2.0 COH units - decrease in visibility
4.0 COH units - soiling evident
6.0 COH units - increasing sensitivity to individuals with asthma and bronchitis

FIGURE 2.9.8

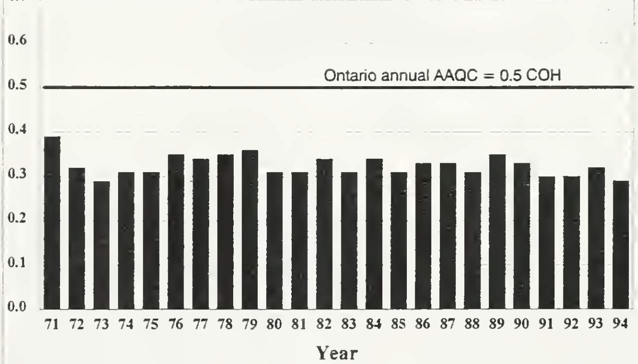
10-Year Trend for SP



Note: 14 Sites operated over 10 years

FIGURE 2.9.9

Long Term Trend for SP



Note: 10 Sites operated over 24 years

Ontario AAQC

1.0 COH unit (24-hours)
0.5 COH unit (1-year)

Method of Monitoring

A continuous paper tape sampler with inlet and flow rate regulated to favour small airborne particles is the method used. SP is determined by drawing a measured volume of air throughout a portion of paper tape. The tape is automatically advanced to produce a reading every hour. The reduction of light transmitted throughout the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled.

Location of Monitoring

Appendix C provides a description of the provincial SP monitoring network. SP was monitored at 35 stations in 1994.

Monitoring Results

The distribution of suspended particles measured across Ontario during 1994, by percentile of the hourly data, the annual average, the maximum one-hour and 24-hour values, and the number of exceedances of the SP criteria are provided in Appendix C.

The lowest annual mean level measured in the province was at the Cornwall monitor (56051) and Sudbury monitor (77203) where the SP average was 0.19 COH unit.

The highest annual mean (0.59 COH unit) and the most exceedances of the 24-hour criterion measured in the province occurred at Station (29102) in Hamilton. The highest measured-hour value (4.9 COH units) was recorded at the Nanticoke monitor (22907).

There was a total of 27 stations (77 per cent) where the 24-hour criterion was exceeded at least once and four stations, three in Hamilton (29001, 29025 and 29102), and one in Toronto (31049), where the annual criterion was exceeded (see Table 2.1).

Trends

The trend in mean annual SP concentrations for the period 1985 to 1994 at selected cities is shown in Table 2.9.3 and summarized for the province in Figure 2.9.8. Fine particulate matter, as determined by SP, has remained relatively constant over the period 1985-1994. The long term trend of SP annual means for the period 1971 to 1994 shows a decrease from 0.37 COH units in 1971 to 0.29 COH units in 1994 (Figure 2.9.9).

Table 2.9.3 10-YEAR TREND FOR SP
Annual Mean (COH units/1000ft)

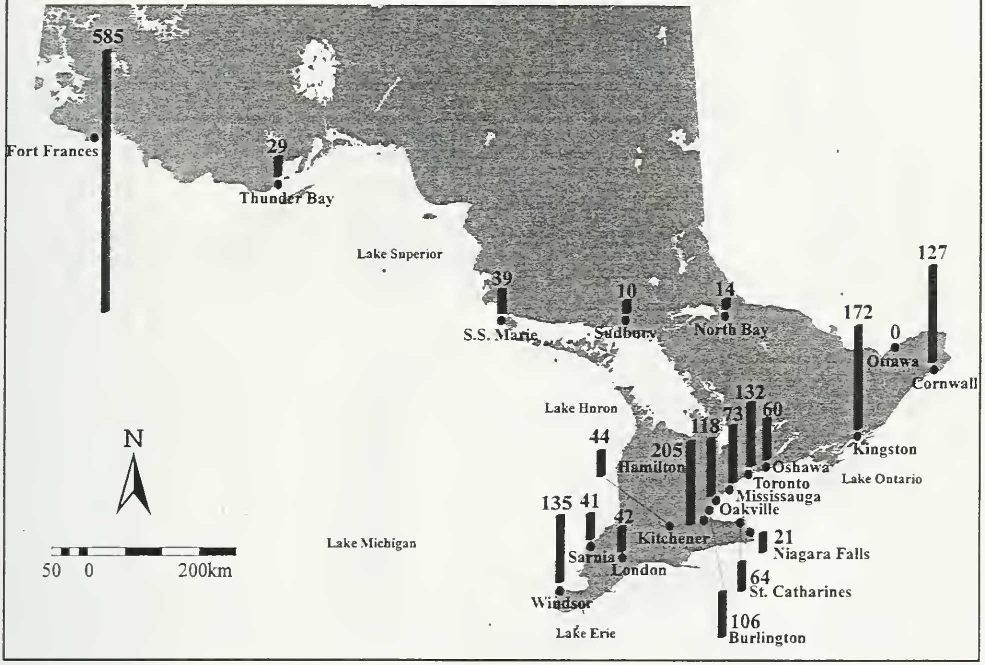
City	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CORNWALL	0.09	0.06	0.04	0.10	0.11	0.19	0.17	0.19	0.22	0.19
ETOBICOKE	0.47	0.54	0.52	0.43	0.59	0.52	0.50	0.46	0.51	0.38
HAMILTON	0.52	0.57	0.55	0.46	0.50	0.42	0.41	0.45	0.48	0.47
LONDON	0.30	0.30	0.27	0.25	0.33	0.28	0.25	0.24	0.25	0.25
NIAGARA FALLS	n/a	0.20	0.18	0.20	0.32	0.25	0.24	0.20	0.21	0.27
NORTH YORK*	0.56	n/a	n/a	0.34	0.41	0.30	0.33	0.31	0.35	0.40
OSHAWA	0.37	0.33	0.37	0.31	0.37	0.37	0.35	0.31	0.36	0.37
OTTAWA	0.14	0.15	0.19	0.23	0.36	0.35	0.25	0.28	0.24	0.22
SARNIA	0.25	0.31	0.29	0.24	0.30	0.28	0.24	0.22	0.20	0.20
SCARBOROUGH	0.34	0.34	0.38	0.37	0.42	0.36	0.34	0.30	0.30	0.34
SUDBURY	0.13	0.16	0.16	0.21	0.18	0.12	0.17	0.17	0.21	0.19
ST CATHARINES	0.26	0.24	0.27	0.23	0.25	0.25	0.25	0.26	0.27	0.25
TORONTO	0.36	0.39	0.38	0.34	0.37	0.38	0.40	0.39	0.42	0.38
WINDSOR	0.41	0.43	0.37	0.44	0.40	0.40	0.30	0.34	0.36	0.28
Composite Mean	**0.31**	**0.31**	**0.31**	**0.31**	**0.35**	**0.32**	**0.3**	**0.3**	**0.32**	**0.3**

*** Site changed location from Science Centre (34002) to North York Central (34020) in 1992.**

n/a - data not available

FIGURE 2.10.1

Number of Hours with Moderate/Poor Air Quality across Ontario 1994



2.10 AIR QUALITY INDEX (AQI)

2.10.1 Characteristics

The Air Quality Index (AQI) is a real-time information system that provides the public with an indication of air quality at 31 sites in 25 major cities across Ontario in 1994. The system has been in operation since June 1988. The AQI is derived from calculations involving pollutant concentrations which have evidence of adverse effects on human health and the environment. These pollutants are sulphur dioxide, ozone, nitrogen dioxide, total reduced sulphur compounds, carbon monoxide and suspended particles. In addition, the Air Pollution Index (API) (Section 2.12) is also included as an AQI sub-index along with the eight-hour average concentration of CO. It should be noted, however, that not all parameters are measured at all AQI sites. The AQI is provided to the public eight times daily; and the reporting frequency is increased to hourly releases when the index at any of the AQI sites reaches 32, the level at which air quality is described as moderate.

2.10.2 Effect

The AQI sub-index is calculated on a hourly basis for each pollutant. The sub-index increases as the air quality deteriorates. The index values, the corresponding categories and the health and environmental effects are given in Table 2.10.1. The highest sub-index at a given time becomes the AQI.

If the index value reaches 50-99, the air quality may have adverse effects on the most sensitive of the human or animal population, or may cause significant damage to vegetation, property, or aesthetic value. An AQI value of 100 or greater may cause adverse effects to the health of a large sector of the exposed population.

2.10.3 Operation of the System

In 1994, there were 31 AQI monitoring sites in Ontario. The larger cities have more than one AQI station. These cities were selected according to population and previous

TABLE 2.10.1: AIR QUALITY INDEX POLLUTANTS AND THEIR IMPACT

	CATEGORY	CARBON MONOXIDE CO	NITROGEN DIOXIDE NO_2	OZONE O_3	SULPHUR DIOXIDE SO_2	SUSPENDED PARTICLES SP	SO_2 + SP (AS MEASURED BY THE API)	TOTAL REDUCED SULPHUR TRS
100-over	Very poor	Increasing cardiovascular symptoms in non smokers with heart diseases. Some visual impairment	Increasing sensitivity of patients with asthma and bronchitis	Light exercise produces respiratory effects in patients with chronic pulmonary disease	Increasing sensitivity in patients with asthma and bronchitis	Increasing sensitivity in patients with asthma and bronchitis	significant respiratory effects in patients with asthma and bronchitis	sensitive individuals may suffer nausea and headaches due to severe odour
50-99	Poor	Increased cardiovascular symptoms in smokers with heart disease	Odour and discoloration. Some increase in bronchial reactivity in asthmatics	Decreasing performance by athletes exercising heavily	Odorous. Increasing vegetation damage	Visibility decreased. Soiling evident	Increased symptoms in patients with chronic respiratory	Extremely odorous
32-49	Moderate	Blood chemistry but no detectable impairment	Odorous	Injurious to many vegetation species e.g. white beans, tomatoes, etc.	Injurious to some species of vegetation	Some decrease in visibility	Injurious to vegetation due to sulphur dioxide	Odorous
16-31	Good	No effects	Slight odour	Injurious to some vegetation species in combination with SO_2 (4 h)	Injurious to some vegetation species in combination with ozone (4 h)	No effects	No effects	Slight odours
0-15	Very good	No effects	No effects	No effects	No effects	No effects	No effects	No effects

TABLE 2.10.2: AIR QUALITY INDEX SUMMARY (1994)

Stn ID	City Name	Number of Hours in AQI Range: V-Good 0-15	Good 16-31	Mod 32-49	Poor 50-99	V-Poor 100+	Number of Hours Pollutant Responsible for AQI ≥32: SP	O_3	TRS	SO_2	API	CO	NO_2
44008	Burlington	7443	1211	106	0	0	28	59	X	0	19	0	0
56051	Cornwall	7575	1058	122	5	0	19	4	101	3	0	0	0
35033	Etobicoke South	7412	1223	96	3	0	80	7	X	0	12	0	0
35003	Etobicoke West	7527	1120	99	0	0	76	18	X	0	5	0	0
62030	Fort Frances	7400	755	509	76	0	1	0	584	X	X	X	X
29000	Hamilton Downtown	6733	1797	203	2	0	97	13	34	0	61	0	0
29105	Hamilton East	7432	1244	58	1	0	37	21	1	0	0	X	X
29114	Hamilton Mountain	7617	1083	60	0	0	8	44	8	0	0	X	0
29118	Hamilton West	7072	1596	92	0	0	63	14	9	0	6	X	0
52020	Kingston +	7493	1031	172	0	0	156	16	X	X	X	X	X
26060	Kitchener	7922	781	44	0	0	9	35	X	0	0	0	0
15001	London	7950	763	42	0	0	15	27	X	0	0	0	0
46110	Mississauga	7503	1156	73	0	0	53	20	X	0	0	0	0
27072	Niagara Falls	8023	716	21	0	0	8	13	X	0	0	X	X
75010	North Bay	8245	403	14	0	0	6	8	X	X	X	0	0
34020	North York Central	7613	1107	40	0	0	33	7	X	0	0	0	0
44015	Oakville	7399	1227	111	7	0	28	28	62	0	0	0	0
45025	Oshawa	7764	899	58	2	0	34	26	X	0	0	0	0
51001	Ottawa	8454	306	0	0	0	0	0	X	0	0	0	0
14064	Sarnia	8066	653	41	0	0	4	25	12	0	0	0	0
71068	Sault-Ste-Marie	8042	493	37	2	0	16	2	21	0	0	X	0
33003	Scarborough	7983	626	43	1	0	22	1	X	0	21	0	0
27067	St Catharines	7847	820	64	0	0	2	62	X	0	0	0	0
77203	Sudbury	8131	425	8	2	0	5	3	0	2	0	0	0
63200	Thunder Bay	8459	225	29	0	0	27	0	2	0	0	0	0
31103	Toronto Downtown	8079	661	18	0	0	12	6	X	0	0	0	0
31120	Toronto West *	6717	615	28	0	0	9	19	X	0	0	0	0
12016	Windsor College	7715	910	131	4	0	55	62	18	0	0	X	X
12008	Windsor University	8238	468	51	3	0	14	40	X	0	0	0	0
36030	York	7434	1157	130	2	0	88	44	X	0	0	0	0

+ Only O_3 and COH are monitored.

* No longer an AQI site (station terminated during fall 1994).

X Pollutant not monitored at this site.

TABLE 2.10.3 NUMBER OF HOURS/DAYS OF MODERATE/POOR AIR QUALITY AT AQI SITES (1994)

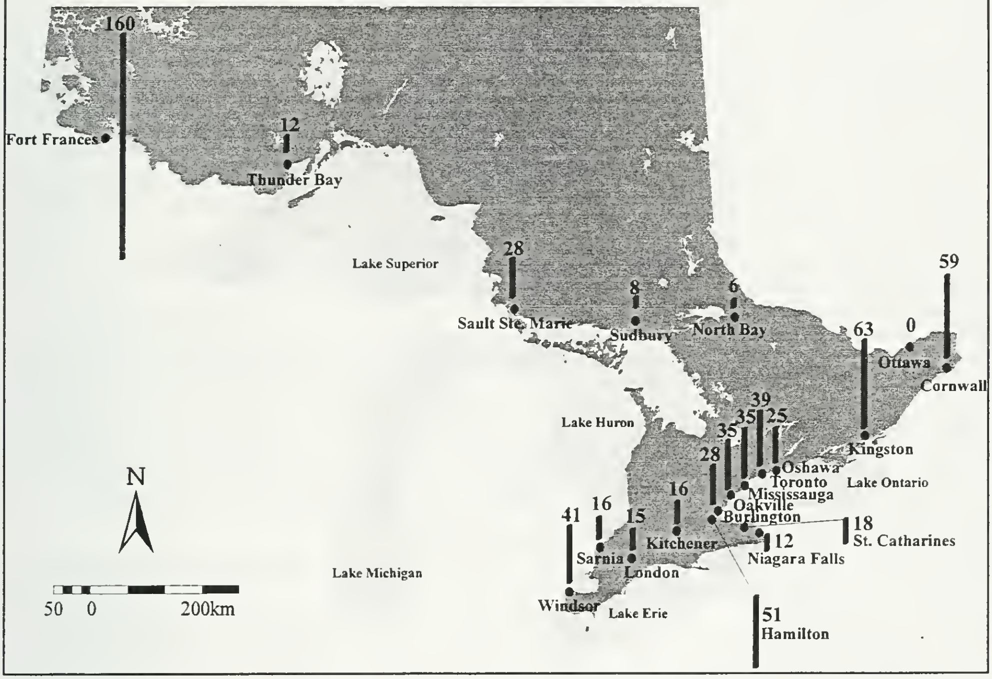
Station ID	City Name	Number of Hours AQI ≥32	Number of Days at Least 1 h AQI ≥32
44008	Burlington	106	28
56051	Cornwall	127	59
35033	Etobicoke South	99	30
35003	Etobicoke West	99	38
62030	Fort Frances	585	160
29000	Hamilton Downtown	205	51
29105	Hamilton East	59	23
29114	Hamilton Mountain	60	20
29118	Hamilton West	92	28
52020	Kingston +	172	63
26060	Kitchener	44	16
15001	London	42	15
46110	Mississauga	73	35
27072	Niagara Falls	21	12
75010	North Bay	14	6
34020	North York Central	40	16
44015	Oakville	118	35
45025	Oshawa	60	25
51001	Ottawa	0	0
14064	Sarnia	41	16
71068	Sault-Ste-Marie	39	28
33003	Scarborough	44	7
27067	St. Catharines	64	18
77203	Sudbury	10	8
63200	Thunder Bay	29	12
31103	Toronto Downtown	18	6
31120	Toronto West *	28	14
12016	Windsor College	135	41
12008	Windsor University	54	11
36030	York	132	39

+ - Kingston - O_3 and COH only pollutants monitored.

* - No longer AQI site (station terminated during fall, 1994).

FIGURE 2.10.2

Number of Days With Moderate/Poor Air Quality Across Ontario (1994)



air quality history. The data from the 31 AQI stations are accessed on a real-time basis by the computer centre at the Environmental Monitoring and Reporting Branch. The computed indices are released to the public and the news media 8 times daily. In addition, AQI forecasts based on the meteorological conditions are issued four times daily. In the event that one of the AQI stations has an index greater than or equal to 32, the AQI information will be released hourly until it drops below 32. When the AQI is 50 or greater, the Medical Officer(s) of Health for the affected region is informed.

2.10.4 Air Quality Index Levels (1994)

The frequency distribution of the hourly AQI, according to descriptive category, and according to the pollutant responsible for AQI ≥ 32, is shown for the 31 AQI monitoring locations across Ontario in Table 2.10.2. From this table, it is evident that at the majority of sites, suspended particles and ozone were the most frequent cause of elevated index readings. Total reduced sulphur compounds were the most frequent cause of high indices in Cornwall (56051) and Fort Frances (62030). Ground-level ozone, which causes the index to be in the moderate/poor categories during the summer, became an issue of concern during the summer of 1994. In that summer, the weather/meteorological conditions were conducive to the production of high concentrations of ground-level ozone. The ozone sub-index contributed for 24 per cent of the total number of AQI exceedances in this year. In fact, during 1994 the number of occasions that the AQI was issued in the moderate/poor categories due to ozone was slightly more than twice of those issued for this pollutant during 1993, the year that previously recorded the least number of ozone exceedances since the inception of the AQI system in 1988. Figure 2.10.1 shows the total number of AQI exceedances recorded at AQI sites for the years 1988-1994. The total number of AQI exceedances during 1994 was the third lowest recorded at AQI sites since the inception of the system in 1988; the total number of exceedances during 1993 was the lowest recorded so far.

Figure 2.10.2 shows the number of days with moderate/poor air quality at AQI sites across Ontario. The number of days during which the air quality was in the moderate/poor range for at least one hour at each AQI site is shown in Table 2.10.3. This table indicates that during 1994, Fort Frances (62030) recorded at least one hour of moderate/poor air quality on approximately 44 per cent of the monitoring days as compared to Kingston (52020) at 17 per cent, Cornwall (56051) at 16 per cent, Hamilton Downtown (29000) at 14 per cent, Windsor College (12016) at 11 per cent, and Ottawa at 0 per cent. Even though Fort Frances individually dominated for the number of AQI days and AQI exceedances it should be noted that there was a considerable reduction of the number of hours of exceedances (approximately 50 per cent reduction) as well as the number of AQI elevated days (9 per cent reduction) from the year 1993. On the other hand, Kingston and Cornwall in southeast Ontario showed a significant increase in the number of hours of exceedances and the number of AQI days (deterioration of air quality) during 1994 due to suspended particles and TRS compounds, respectively.

2.11 AIR QUALITY ADVISORY

In Ontario, during late spring of 1993, Environment Canada and the Ontario Ministry of Environment and Energy commenced issuing air quality advisories to the public in Ontario when elevated air pollution levels are forecast due to ground-level ozone. Ground-level ozone is a major component of photochemical smog.

Air quality advisories encourage people to contribute to pollution prevention and "Spare the Air". People are urged to take action to prevent further deterioration of air quality. The advisories also include information about the effects of air pollution on the environment and human health.

This program builds on the existing Air Quality Index (AQI) system. The advisories are sent through existing distribution networks used by both partners for weather and air quality messages.

The advisories are based on the AQI forecasts of ground-level ozone prepared by the Ontario Ministry of Environment and Energy. They are issued on a regional basis in the afternoon the day before elevated ground-level ozone levels are expected.

Advisories are delivered to the public through the media, Environment Canada weather offices and Weather radio, and are available at local offices of the Ontario Ministry.

During 1994, two Air Quality Advisories were issued (June 16-19, and July 19-20).

2.12 AIR POLLUTION INDEX (API)

2.12.1 Characteristics

The API continues to be the basis of an alert and control system to warn of deteriorating air quality and is derived from 24-hour running averages of SO_2 and SP. Research studies have linked respiratory illness to elevated concentrations of SO_2 and particulates.

2.12.2 Legislation

Regulation 346 under the Ontario *Environmental Protection Act* (1971) authorizes the Ministry of Environment and Energy to order any point source not essential to public health or safety to curtail or cease its operations when air pollution levels occur which may be injurious to health.

2.12.3 Operation of the System

The API is computed each hour based on the past 24 hourly values for SO_2 and SP. If the index reaches a

TABLE 2.12.1

NUMBER OF OCCASIONS API ≥32 AT SITES ACROSS ONTARIO (1990 - 1994)

Station	1990	1991	1992	1993	1994
Burlington	2 (34)				1 (36)
Etobicoke West					2 (33)
Etobicoke South					1 (37)
Hamilton Downtown	2 (42)	1 (34)	3 (35)	3 (37)	3 (37)
Hamilton East				1 (33)	
Hamilton Mountain	1 (38)			1 (33)	
Hamilton West	1 (32)				1 (34)
Scarborough					1 (42)
Sudbury	2 (42)				
Windsor University					1 (32)

NOTE: Maximum API value is given in the parentheses value of 32 and if the duty meteorologist predicts a continuation of adverse atmospheric conditions for at least six hours, an Air Pollution Advisory is issued. Owners of significant sources of pollution are advised to prepare for possible curtailment of operations.

If the index reaches 50, and if at least six hours of adverse atmospheric conditions are forecast, owners of major sources may be ordered to curtail operations. This is the First Alert Level.

A Second Alert is issued at an API of 75, and further curtailment may be ordered.

The Air Pollution Episode Threshold Level occurs at an API of 100. If atmospheric conditions are not expected to improve for at least six hours, owners of all sources not essential to public health or safety may be ordered to cease operations.

2.12.4 Air Pollution Index Levels

A history of the Air Pollution Index levels over the last 5 years of its operation is provided in Table 2.12.1. The table shows that Windsor University (12008), Hamilton-Downtown (29000), Hamilton-West (29105), Scarborough (33003), Etobicoke-West (35003), Etobicoke-South (35033), and Burlington (44008) API sites recorded levels in the advisory range during 1994. The maximum value (API=42) was recorded at Scarborough. The Hamilton Downtown site (29000) is the only API that recorded API exceedances each year during the period (1989-1994). Toronto Downtown site has not recorded any API exceedances during this period.

2.13 LAMBTON INDUSTRIAL METEOROLOGICAL ALERT (LIMA)

The Lambton Industry Meteorological Alert System (LIMA) is part of the *Environmental Protection Act* - Reg. 350. The application of this alert is limited to that part of the county of Lambton, bounded by Lake Huron, the St. Clair River, the King's Highway known as No. 80, the roadway known as Moore Township Road 31 and its continuation through that part of the King's Highway known as No. 40 and Lambton County road 27, which includes the City of Sarnia.

The Minister may declare an alert when the 24-hour running average sulphur dioxide concentration at any station in the Lambton Industry Meteorological Alert system reaches 0.07 ppm and meteorological forecasts indicate a continuation for six hours or more of weather conditions conducive to elevated SO_2 concentrations. The alert is issued at 0.07 ppm so as to prevent exceedance of the Ontario 24-hour SO_2 AAQC (0.10 ppm).

Two monitoring sites are located in Sarnia (Front Street and Centennial Park), one in Corunna (River Bend) and one in Michigan (Port Huron).

During 1994 the alert was issued on seven occasions. The longest duration of the alert was 30 hours lasting from 0400 EST on November 4, 1994 to 1000 EST November 5, 1994. The maximum 24-hour running average SO_2 concentration during this episode reached 0.124 ppm and was recorded at the Front Street monitoring site. This concentration value reported at Front Street site was also the highest 24-hour running average SO_2 recorded at the monitors in the Lambton Industry Alert System during 1994.

Of the seven alerts issued during 1994 for the Sarnia area, six were based on SO_2 measurements at Front Street and the remaining one was based on measurements at Centennial Park. The number of LIMA alerts called over the last 11 years is displayed in Table 2.13.1.

TABLE 2.13.1

LAMBTON INDUSTRY METEOROLOGICAL ALERT SUMMARY 1984-1994

Year	Alerts Called	Average Duration (Hours)
1984	7	15
1985	3	16
1986	8	14
1987	0	-
1988	5	24
1989	3	12
1990	9	16
1991	8	23
1992	3	13
1993	7	25
1994	7	19

2.14 Urban Air Toxics (Organics)

2.14.1 Background

Ontario Ministry of Environment and Energy monitoring sites of airborne toxic organic chemicals, including semi-volatile polycyclic aromatic hydrocarbons (PAH), polychlorinated dibenzo-p-dioxins and furans (PCDD/PCDF) and volatile organic compounds (VOC), are shown in Figure 2.14.1. The PAH and VOC are measured in urban and industrial source areas because select compounds from these chemical groups are potentially harmful to the ecosystem and human health and are known to be present in the ambient environment. VOC can also contribute to photochemical production of ground-level ozone. The PCDD/PCDF, also potentially harmful to human health, are measured in Windsor and Dorset only, to provide a comparison between urban and rural background concentrations.

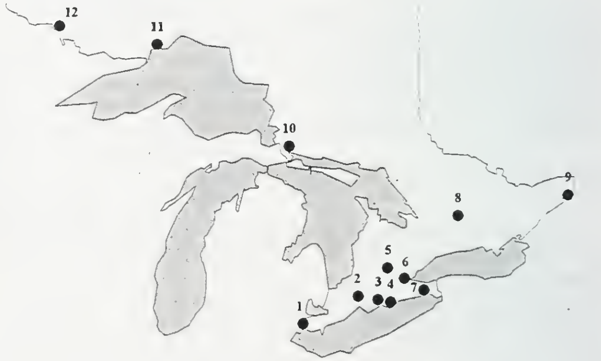
Measurement data are available for some locations for upwards of five years, while other sites have shorter duration data. For some compounds it may appear that trends in concentration are becoming apparent, while others display highly variable concentrations from year to year. A significant portion of the target chemicals typically are not detected routinely. It must be noted that before any conclusions regarding trends in concentration of airborne urban toxics are stated, it is necessary to base any interpretation on a database comprised of at least ten years of measurements.

Measurements for ten VOC known or suspected of being human carcinogens are compared to previous years' results as are measurements for the PCDD/PCDF. Benzo[a]pyrene data are only available until 1993. Where available, measurements made by the Ontario Ministry of Environment and Energy are supplemented with data obtained from Environment Canada.

FIGURE 2.14.1

Location of Toxic Organic Chemicals Monitoring Sites (1994)

Map Reference	Site Name	VOC	B(a)P	Dioxins/ Furans
1	Windsor	*	*	*
2	London	*		
3	Simcoe		*	
4	Nanticoke	*	*	
5	Elmira	*		
6	Hamilton	*	*	
7	Welland		*	
8	Dorset	*		*
9	Cornwall	*	*	
10	Sault Ste. Marie	*	*	
11	Thunder Bay	*	*	
12	Fort Frances	*		



2.14.2 Monitoring Methods

To measure VOC, air is drawn throughout a multi-stage sorbent cartridge at a known flow rate for 24 hours to trap the compounds of interest. The sampling schedule for VOC is once every 12 days. Samples are sent to the Ministry's Laboratory Services Branch for analysis by gas chromatography (GC). Until the end of 1992, the detector used was a flame ionisation detector (GC-FID). In 1993 the detector was changed to a mass selective detector (GC-MSD).

For the semi-volatile PAH and PCDD/PCDF, air is drawn through a high-volume sampler modified to accept a vapour trap downstream from a particulate filter. Particles are trapped on a teflon-coated glass fibre filter. Vapour phase PAH are trapped on a polymeric resin (XAD-2) while vapour phase dioxins and furans are trapped on a polyurethane foam plug. Twenty-four hour measurements are taken every 12 days and 24 days for PAH and PCDD/PCDF, respectively. The Ministry's Laboratory Services Branch analyses PAH by GC-MSD and the PCDD/PCDF by GC/MS/MS (gas chromatography tandem mass spectrometry). Prior to March 1991, PAH analysis was by GC-FID.

2.14.3 Effects

Of the ten VOC reported here,

TABLE 2.14.1
Volatile Organic Compound Names, Common Synonyms, Detection Limits and Carcinogenicity.

Compound Name	Common Synonym	Detection Limits ($\mu g/m^3$)			Carcinogenicity
		(to 1992)	(1993)	(1994)	
benzene		0.1	0.05	0.02	KHC
vinyl chloride	chloroethylene	0.1	0.50	0.05	KHC
1,3-butadiene	vinylethylene	0.1	0.05	0.05	SHC
styrene	vinylbenzene	0.1	0.20	0.10	SHC
1,2-dibromoethane	ethylene dibromide	0.1	0.10	0.05	SHC
trichloromethane	chloroform	0.3	0.05	0.02	SHC
1,2-dichloroethane	ethylene dichloride	0.1	0.05	0.02	SHC
tetrachloroethylene	perchloroethylene	0.1	0.20	0.05	SHC
trichloroethylene	trichloroethene	0.1	0.10	0.05	SHC
carbon tetrachloride	tetrachloromethane	0.8	0.05	0.02	SHC

KHC: Known Human Carcinogen, SHC: Suspected Human Carcinogen.

two are known human carcinogens (capable of inducing cancer) and eight are suspected of being human carcinogens. Table 2.14.1 lists the ten target VOC selected, some common synonyms, typical analytical detection limits (in $\mu g/m^3$), and their carcinogenicity.

Some of the chemicals on the list are also mutagens, that is, the chemicals are capable of causing abrupt genetic changes within cells, the changes then being reproduced when the cell divides.

The PAH Benzo[a]pyrene and the PCDD/PCDF have also been shown to be carcinogens.

2.14.4 Sources and Sinks

Small amounts of some of the chemicals discussed here are produced naturally. For instance, benzo[a]pyrene and the dioxins and furans are formed in forest fires.

Benzene, a component of gasoline, is emitted to the atmosphere throughout the production, distribution, and marketing of gasoline, as well as throughout the operation of gasoline powered motor vehicles and off-road equipment (for example, lawnmowers, dirt bikes, and watercraft). Other smaller sources of benzene include the manufacture of detergents, plastics and resins, flavours and perfumes, paints and coatings, and in coal processing and coal coking, food processing and photographic chemicals.

Vinyl chloride is used in the manufacture of the rigid plastic PVC and in adhesives for plastics. It is also emitted from landfill sites.

1,3-butadiene is used in the manufacture of styrene-butadiene rubber, latex paints, and resins. This pollutant is also found in automobile exhaust and as a product of biomass combustion.

Styrene is used in the manufacture of synthetic rubber, Acrylonitrile-Butadiene-Styrene (ABS) plastics, resins, adhesives, and insulators. Styrene emissions have also been measured in automobile exhaust and from building materials.

1,2-dibromoethane is used as an insecticide and also as a grain and fruit fumigant. In the past, this chemical was used as a lead scavenger in leaded gasoline.

Trichloromethane is used in the manufacture of fluorocarbon refrigerants, propellants, plastics, anesthetics and pharmaceutical. It is also used as a solvent, a sweetener, a fumigant, and in the manufacture of electronic circuitry.

1,2-dichloroethane is a constituent in paint, varnish, finish removers, and soaps and scouring compounds. It is also used in metal degreasing, tobacco flavouring, and as an intermediate insecticidal fumigant. This chemical is found in cosmetics (nail lacquers) and as a food additive as a result of its use in extracting spices such as paprika and turmeric.

Tetrachloroethylene, trichloroethylene, and carbon tetrachloride are all solvents used in the dry-cleaning process. Tetrachloroethylene and trichloroethylene are also used as

Table 2.14.2 VOC Concentration Statistics (1989-1994) for Ontario Communities

Compound: Benzene

Ambient Air Quality Criterion: Not available

Year	24-Hour Maximum Concentration (µg/m^3)	Community	Highest Annual Average Concentration (µg/m^3)	Community
1989	37.4*	Sarnia	5.1*	Ottawa
1990	25.6*	Sarnia	5.3*	Sarnia
1991	28.4*	Sarnia	8.0*	Hamilton
1992	52.6	Hamilton	7.3	Hamilton
1993	14.9	Hamilton	4.2	Hamilton
1994	42.0	Hamilton	6.1	Hamilton

Observations: Most 1994 annual averages fall between 1.0 µg/m^3 and 5.0 µg/m^3. The lowest annual average (0.3 µg/m^3) was measured in Dorset, in the District of Muskoka, which is considered to be a background control site.

* Environment Canada data

Compound: 1,3-butadiene

Ambient Air Quality Criterion: Under development

Year	24-Hour Maximum Concentration (µg/m^3)	Community	Highest Annual Average Concentration (µg/m^3)	Community
1989	6.0*	Sarnia	0.5*	Sarnia; Ottawa
1990	4.1*	Sarnia	0.5*	Sarnia
1991	4.9*	Sarnia	0.5*	Sarnia;Oakville
1992	1.7	Oakville	0.4	Oakville
1993	0.7	Cornwall	0.1	Numerous
1994	0.5	London	<0.1	Numerous

Observations: Most 1994 annual averages fall between 0.02 µg/m^3 and 0.07 µg/m^3. This highly reactive chemical is often not detected in more than one-half of the samples collected at a given site.

* Environment Canada data

Compound: Styrene

Ambient Air Quality Criterion: 400 µg/m^3 (24-hour average)
Point of Impingement Standard: 400 µg/m^3 (½ hour average)

Year	24-Hour Maximum Concentration (µg/m^3)	Community	Highest Annual Average Concentration (µg/m^3)	Community
1989	4.6	North York	0.7	North York;Windsor
1990	23.7	North York	1.2	North York
1991	13.0	Mississauga	1.5	Mississauga
1992	1.6	Windsor	0.8	Cornwall
1993	7.6	Cornwall	0.9	Cornwall
1994	1.2	Hamilton	0.4	Cornwall

Observations: Most 1994 annual averages fall between not detected to 0.10 µg/m^3. Typically, styrene is detected in less than one-half of the samples collected at a given site. All of the samples collected at the Cornwall site detected styrene.

solvents for fats, waxes, greases, rubbers, gums, and for removing caffeine from coffee. Tetrachloroethylene is used in the manufacture of paint removers, printing inks, and fluorocarbons. Carbon tetrachloride is used as a metal degreasing solvent and in the manufacture of refrigerants, aerosols, propellants, fire extinguishers, and also as a fumigant.

The sources of volatile organic compounds mentioned above should be considered representative, not exhaustive. Some of the stated uses may have been phased out already, for example, it may no longer be common practice to decaffeinate coffee

Table 2.14.2 (Cont'd) VOC Concentration Statistics (1989-1994) for Ontario Communities

Compound: Tetrachloroethylenee

Ambient Air Quality Criterion: 4000 µg/m^3 (24-hour average)

Point of Impingement Standard: 10000 µg/m^3 (½ hour average)

Year	24-Hour Maximum Concentration (µg/m^3)	Community	Highest Annual Average Concentration (µg/m^3)	Community
1989	40.7*	Ottawa	5.6*	Ottawa
1990	55.7	Hamilton	8.5	Hamilton
1991	26.9*	Ottawa	4.5*	Ottawa
1992	33.0	Hamilton	2.5	Hamilton
1993	21.1	Hamilton	2.2	Hamilton
1994	7.1	Hamilton	1.2	Hamilton

Observations: Most 1994 annual averages fall between 0.1 µg/m^3 and 0.5 µg/m^3 for this common dry-cleaning solvent.

* Environment Canada data

Compound: Carbon tetrachloride

Ambient Air Quality Criterion: 600 µg/m^3 (24-hour average)

Point of Impingement Standard: 1800 µg/m^3 (½ hour average)

Year	24-Hour Maximum Concentration (µg/m^3)	Community	Highest Annual Average Concentration (µg/m^3)	Community
1989	8.7	Windsor	1.1*	Sarnia
1990	12.0	Toronto	1.1*	Sarnia
1991	13.4	Oakville	5.0	Hamilton
1992	31.7	Hamilton	5.2	Cornwall
1993	11.3	Cornwall	2.2	Cornwall
1994	6.6	Cornwall	1.9	Cornwall

Observations: Carbon tetrachloride has a long atmospheric lifetime and average concentrations of about 0.4 µg/m^3 are observed at nearly all sites (except Cornwall) across the province.

* Environment Canada data

with the solvents tetra- and trichloroethylene.

Benzo[a]pyrene and other PAH are products of the incomplete combustion of organic materials, such as, gas, oil, and coal, wood, and tobacco. B[a]p is emitted from fossil fuel-fired power plants, industrial processes, automobile engines (internal combustion and diesel), forest fires, and cigarettes, cigars, and pipes.

Examples of known sources of dioxins and furans include municipal solid waste and biomedical incinerators, automobiles, and wood combustion. PCDD/PCDF are also formed as unwanted byproducts in the production of herbicides (Agent Orange being the most well known), and chlorophenol-containing fungicides, insecticides, and mould inhibitors. One of the most important uses for the tri-, tetra-, and penta-chlorophenols has been wood preservation.

Removal of these chemicals from the atmosphere is largely through the processes of wet and dry deposition. Wet deposition occurs when the compound is brought to the ground in rain or snow, and dry deposition is the process whereby the molecules are brought to the surface by turbulence in the atmosphere. The rate at which dry deposition occurs depends very strongly on the form of the chemical in the atmosphere, that is, whether it is present as a gas or a particle. If present as a particle, the dry deposition rate also depends on the size of the particle.

Some of these compounds are also removed from the atmosphere by chemical reactions taking place in

Table 2.14.2 (Cont'd) Benzo[a]pyrene Concentration Statistics (1989-1993) for Ontario Communities

Compound: Benzo[a]pyrene

Ambient Air Quality Criterion: 1.1 ng/m^3 (24-hour average, single source)
700 µg/m^3 (24-hour average, all sources)
Point of Impingement Standard: 3.3 ng/m^3 (½ hour average, single source)

Year	24-Hour Maximum Concentration (µg/m^3)	Community	Highest Annual Average Concentration (µg/m^3)	Community
1989	2.2	Windsor	1.0	Windsor
1990	19.9	Sault Ste. Marie	3.3	Sault Ste. Marie
1991	22.6	Welland	3.9	Welland
1992	176.9	Sault Ste. Marie	20.9	Sault Ste. Marie
1993	24.2	Sault Ste. Marie	2.0	Hamilton

Observations: Only a limited number of sites measured benzo[a]pyrene prior to 1993 and these sites were located near known sources. The concentrations reported should not be considered typically urban.

the presence of sunlight.

2.14.5 Ambient Levels Measured

The 1994 measurements for the compounds of interest are compared to previous years' results and to ambient air quality criteria and point of impingement interim standards, if available, in Table 2.14.2. Only those compounds consistently measured above analytical detection limits appear in tabular form; information about urban air toxics frequently measured at concentrations at or near their detection limits are described in anecdotal form. The following caveats should be taken into consideration when interpreting the results presented:

- Not all chemicals are measured at all monitoring sites. It is possible that a community's airborne toxics profile is not representative of its sources if the toxins are not measured.

- Concentrations of airborne chemicals in urban and industrial areas are highly variable from site to site, depending particularly on how close a monitoring station is to a source or sources. In some cases, monitors are purposely located near known or suspected sources and the relatively high concentrations obtained are not unexpected. The sampling frequency also influences the statistics reported, particularly the 24-hour maximum concentration.

- Concentrations of airborne chemicals in urban and industrial areas are also highly variable from year to year, depending upon variable emission types and emission rates.

- In some cases, the period of record extends from 1989 to 1994, however, most sites have a shorter sampling record. Changes in improved detection limits influence the statistics calculated over time.

__Results for Other Chemicals__

i) Dioxins and Furans:

Airborne dioxins and furans measurements are made at an urban (Windsor) and a rural (Dorset) monitoring site for comparison purposes. As one might expect, the urban airborne dioxins and furans concentrations, expressed as *pg* Toxicity Equivalent/m^3 (TEQ), are slightly greater than the rural concentrations. Toxicity Equivalence (TEQ) applies international toxicity equivalency factors to the various dioxins and furans isomers using the most toxic form 2,3,7,8-tetrachlorodibenzo-*p*-dioxin as a reference. The method for calculating the Toxicity Equivalent (TEQ) is explained in the "Summary of Point of Impingement Standards, Ambient Air Quality Criteria (AAQCs), and Approvals Screening Levels (ASLs)" available from the Ontario Ministry of Environment and Energy, Standards Development Branch.

Based upon measurement data collected between 1991-1994, the following has been observed:

- All results from both sites are substantially below the Ontario Ambient Air Quality Criterion (24-hour average) of 5 *pg* TEQ/m^3.

- The 1994 maximum TEQ measured in Windsor was 0.08 *pg* TEQ/m^3. This can be compared to a maximum of 1.15 *pg* TEQ/m^3 measured in Windsor in 1991. The 1994 annual average TEQ in Windsor is 0.05 *pg* TEQ/m^3 (± 0.02 *pg* TEQ/m^3). The overall average TEQ in Windsor for 1991-1994 is 0.13 *pg* TEQ/m^3 (± 0.20 *pg* TEQ/m^3).

- The 1994 maximum TEQ measured in Dorset was 0.05 *pg*

TEQ/m^3. This can be compared to a maximum of 0.07 *pg* TEQ/m^3 measured in Dorset in 1991. The 1994 annual average TEQ in Dorset is 0.01 *pg* TEQ/m^3 (± 0.01 *pg* TEQ/m^3). The overall average TEQ in Dorset for 1991-1994 is 0.02 *pg* TEQ/m^3 (± 0.02 *pg* TEQ/m^3).

- The most toxic form of dioxins and furans, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, was never detected in any of the 48 samples collected at Dorset during 1991-1994. Conversely, this form of dioxin has been positively detected in 16 of the 40 samples collected in Windsor. However, the concentrations of this dioxin isomer are almost at the detection limit and only marginally influence the calculation of the TEQ.

- Octachlorodibenzo-*p*-dioxin, a single isomer, has been positively detected in every Windsor and Dorset sample since sampling began, but even at relatively higher concentrations it contributes only a small portion of the TEQ. The isomers 2,3,4,7,8-pentachlorodibenzo-furan, 2,3,7,8-tetrachlorodibenzo-furan and 1,2,3,7,8-pentachlorodibenzo-p-dioxin contribute almost one-half of the TEQ for samples collected in Windsor and Dorset.

ii) Vinyl chloride, 1,2-dibromoethane, trichloromethane, 1,2-dichloroethane and trichloroethylene:

These compounds are often not detected at monitoring sites across the province. When these compounds are detected, they are often measured within a factor of 5 of their detection limits, hence they would be measured at levels several tens to hundreds times lower than their AAQC.

TABLE 2.15.1 Legal SO_2 Emission Limits (kilotonnes)

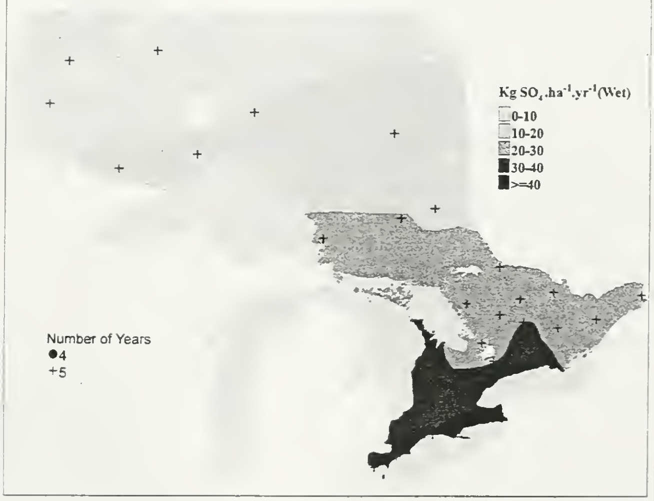
Source	Regulation	1986	1994
INCO	660/85	685	265
Falconbridge	661/85	154	100
Ontario Hydro	355/90	370	175
Algoma Iron Ore Division (Wawa)	663/85	180	125
	Total	1389	665

Notes:

1. Ontario is committed to provincial emissions cap of 885 kilotonnes SO_2 per year from all sources.
2. Ontario Hydro must meet a combined limit of acid gas (SO_2 + NO) emissions of 215 kilotonnes for 1994 and beyond.

FIGURE 2.15.1

Spatial Distribution of Ontario's Wet Sulphate Deposition 1981 - 1985



Future Work

The Ministry is endeavouring to develop methods to measure two additional volatile organic compounds, dichloromethane and formaldehyde, which are suspected human carcinogens. Dichloromethane is used extensively in paint strippers and as a degreasing solvent. It is also used in the manufacture of aerosols, photographic film and synthetic fibres and as a treatment for textiles and leathers. Formaldehyde is used in the production of certain plastics and as a fungicide and preservative (formalin is an aqueous solution of formaldehyde). Formaldehyde is emitted in the exhaust of alcohol-fuelled vehicles and has been detected in the exhaust of diesel-engine vehicles.

These chemicals are routinely measured by Environment Canada in several urban locations in Ontario, using a different measurement technique than that employed by the Ministry.

2.15 ACID DEPOSITION

The objective of the Countdown Acid Rain program, initiated in 1985, was to reduce the amount of sulphate in precipitation to a target level of 20 kilograms per hectare per year, in order to protect all but the most sensitive lakes from the effects of acidification. The target loading was used to develop federal, provincial and international sulphur dioxide (SO_2) control agreements.

To meet the deposition target in Ontario and eastern Canada, the Countdown Acid Rain program required emission reductions from the four biggest Ontario SO_2 sources - INCO, Falconbridge, Algoma-Iron Ore Division (Wawa) and Ontario Hydro. The regulated emission limits are summarized in Table 2.15.1.

Commitments made under the Countdown program were met or exceeded by the regulated companies. Actual 1994 emissions for all companies were substantially lower than required by the regulations. Actual 1994 SO_2 emissions were as follows: INCO - 162 kilotonnes; Falconbridge - 54 kilotonnes; Ontario Hydro - 106 kilotonnes; Algoma-Iron Ore Division (Wawa) - 34 kilotonnes, for a total of 356 kilotonnes. Total SO_2 emissions from all sources in Ontario were 618 kilotonnes.

Ontario continues to monitor acid deposition impacts by defining spatial and temporal acid deposition trends within the province. A network of 17 cumulative 28-day deposition sampling sites, with one daily site at Dorset, has been maintained to monitor the effectiveness of the Canadian and United States SO_2 emission control programs.

The spatial and temporal trends for Ontario's wet sulphate deposition and acidity, as measured by pH, are shown in Figures 2.15.1 to 2.15.3 and

FIGURE 2.15.2

Spatial Distribution of Ontario's Wet Sulphate Deposition 1985 - 1989

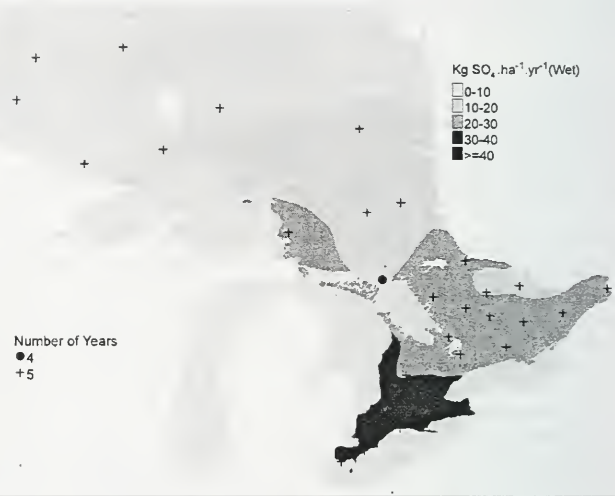


FIGURE 2.15.3

Spatial Distribution of Ontario's Wet Sulphate Deposition 1989 - 1993

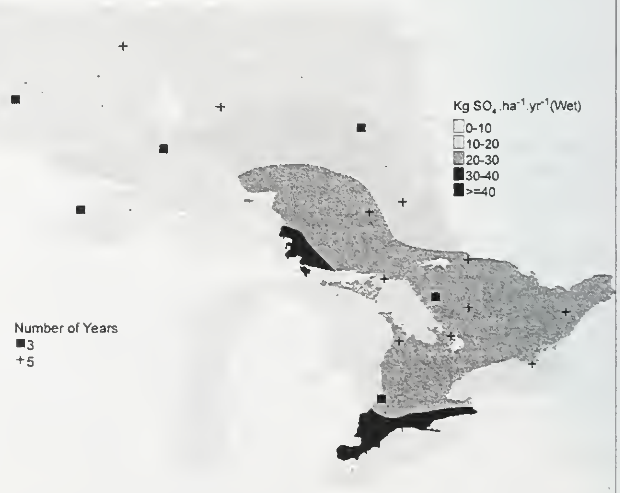


FIGURE 2.15.4

Spatial Distribution of Ontario's pH 1981 - 1985

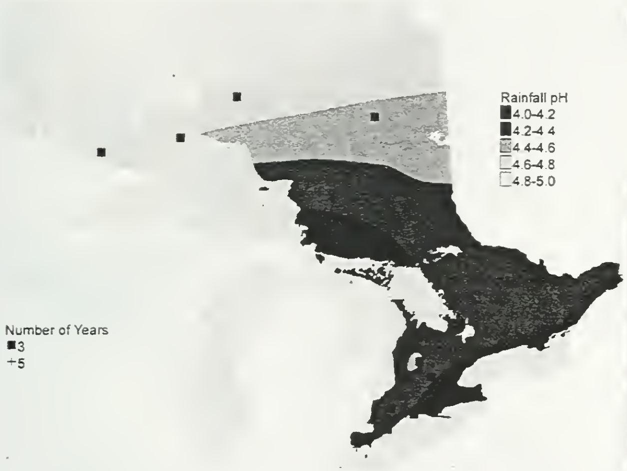
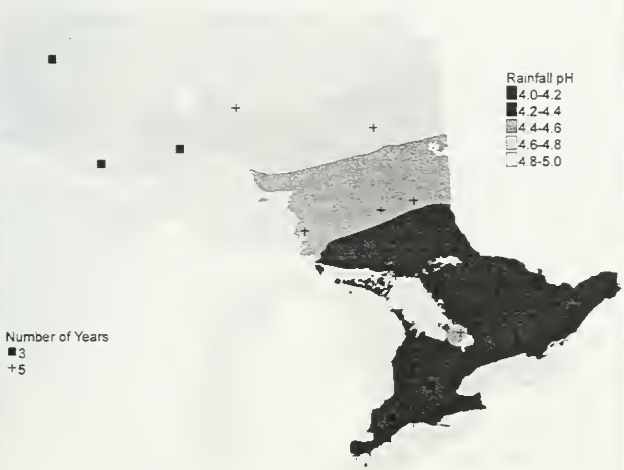


FIGURE 2.15.5

Spatial Distribution of Ontario's pH 1985 - 1989



Figures 2.15.4 to 2.15.6, respectively. These figures indicate:

i) Northern Ontario has experienced lower wet sulphate deposition than the rest of the province, being typically less than 10 kilograms per hectare per year.

ii) The area of highest wet sulphate deposition (i.e., > 40 kg/ha/yr) no longer exists, and the area of moderately high wet sulphate deposition (i.e., 30-40 kg/ha/yr) has been reduced significantly. The area bounded by 20 kg/ha/yr wet sulphate deposition has not changed appreciably over time, even though concentrations have decreased typically by about 2 per cent per year. This phenomenon may be an artifact of an increase in precipitation amount offsetting the decrease in concentration.

iii) A distinct north-south gradient exists for pH. Although the area represented by lowest pH disappeared by 1985, the areas of medium acidity (pH 4.2-4.6) remain and have shown little change in geographical coverage. Despite reductions in wet sulphate deposition, precipitation acidity remains relatively the same as it was in the mid-1980's. One possible explanation for this occurrence is only a marginal, concurrent decrease in acidifying nitrogen compounds over time.

2.16 RADIATION

Environmental radioactivity in Ontario comes from a variety of natural and man-made sources. Natural sources include cosmic rays from the sun and outer space, naturally occurring radioactive elements (such as thorium and uranium) in soils and rocks, and radon in the air. The primary man-made source is the residue from atmospheric nuclear weapons testing. The operation of nuclear generating stations by Ontario Hydro also results in radioactive gases and particulates released to the atmosphere and tritium to the air and water.

Radioactivity can be a health hazard, and this hazard increases with increasing radiation dose; the primary adverse effect of low doses of radiation is an increased risk of certain types of cancer. The International Commission on Radiation Protection (ICRP) has recommended that a linear, no-threshold relationship holds between this risk and the dose, and that the cancer risk be taken as 5 per cent per sievert. (A sievert is equal to 100 rem.)

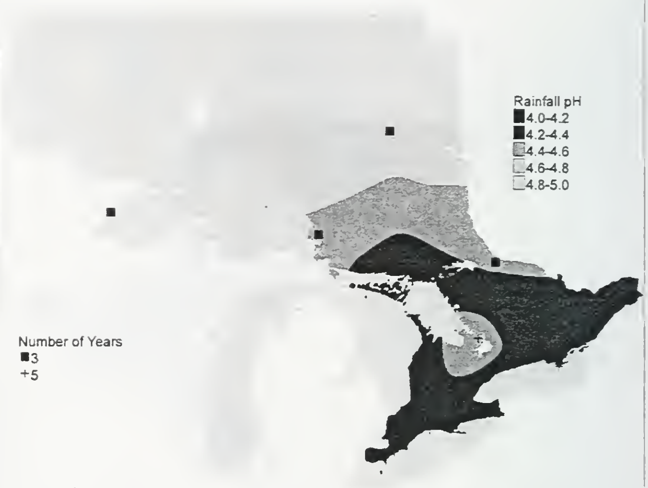
The average background radiation dose in Ontario has been estimated to be 3.6 millisieverts (mSv), or 3.6 thousandths of a sievert. This is made up of 3 mSv from natural sources, 0.1 mSv from man-made sources, including fallout, and the long-term yearly average from medical exposures of 0.5 mSv. The additional annual risk of cancer per Ontario resident, then, from the total "background" radiation is 0.018 per cent, or 1.3 per cent over a lifetime, compared to the approximately 25 per cent total lifetime cancer risk.

Background radiation is not uniformly distributed over Ontario; the Canadian Shield contains considerably greater amounts of uranium and thorium than do the soils of southern Ontario. Atmospheric radioactivity is, however, fairly uniformly distributed over the province; the contribution of atmospheric sources to the total background radiation dose is of the order of 300-600 *millionths* of a sievert.

Radioactive emissions from Ontario Hydro nuclear generating stations are regulated by the Atomic Energy Control Board (the federal regulatory agency). These emissions must result in a dose of less than 5 mSv per year to the most exposed individual; this quantity is known as the public dose limit. In practice, the doses due to the operation of Hydro's nuclear stations are a very small percentage of this legal limit.

FIGURE 2.15.6

Spatial Distribution of Ontario's pH 1989 - 1993



Ontario Hydro, the Ministry of Labour and Health Canada carry out programs of environmental radiological monitoring to ensure that emissions of radioactive materials are under proper control and that doses to the public remain acceptably small.

These data indicate that tritium does appear in concentrations that are statistically greater than the background at all the operating nuclear stations. Tritium has been observed in air, precipitation, lake or river water (including drinking water), and local produce, including milk. Carbon-14 has been detected in food, vegetation and milk. The contribution of noble gases, iodine-131 and other particulates to the public dose cannot be reliably distinguished from natural background levels; however, based on the radiological emissions reported by the nuclear stations, estimates can be made of this contribution.

The highest additional doses due to nuclear generating stations occur around the Pickering station. The main contributors are noble gases (approximately 10 millionths of a sievert), Carbon-14 (3 millionths of a sievert) and tritium (2 millionths of a sievert). The total, 15 millionths of a sievert, represents 0.3 per cent of the legal limit and 0.42 per cent of the Ontario background radiation. Releases at Bruce and Darlington are considerably lower; there, the releases are 0.17 per cent and 0.06 per cent, respectively, of the background radiation levels.

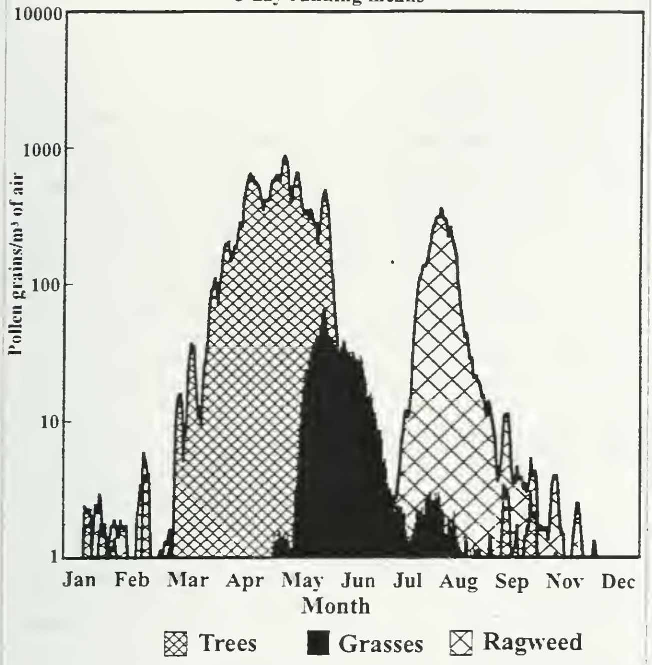
The accident at Pickering in December, 1994, where several tons of radioactive (tritiated) heavy water was spilled inside the plant did not result in any measurable increase in emissions of tritium to the atmosphere over and above the normal, day-to-day releases.

We may conclude that the

FIGURE 2.17.1

Seasonal Distribution of Airborne Pollen

Toronto 5 year average
5 day running means



Source: University of Toronto

radiological quality of Ontario's air is good.

2.17 AEROALLERGENS: POLLEN

2.17.1 Characteristics

Pollen grains are the male sperm cell used in plant reproduction. Their purpose is to carry genetic material from male to female organ, within or between individuals. Plants transfer pollen grains in three ways, by wind, water, or animal. Wind pollination relies solely on the lifting action of wind currents and their direction to disperse pollen grains. To compensate for this less direct and less reliable mode of transfer, wind pollinated plants produce and release vast quantities of pollen. While some pollen grains are successful in finding a receptive female organ, most are scattered on other surfaces including human respiratory mucosal membranes. Pollen grains carry on their surface a suite of proteins, such as those involved in pollen-pistil recognition systems, that are released quickly when in contact with moist surfaces. Some of these proteins can cause genetically predisposed people to become sensitized to them. Subsequent exposures elicit adverse allergic reactions.

Because of the coordination of timing of reproduction in plants, pollen grains of particular types of plants are present in the atmosphere at specific times. There are three main seasons for wind pollinated plants - spring trees, summer grasses and fall ragweed, (see Figure 2.17.1). Peak pollen levels are usually experienced for only a few days when the pollination of certain species is at maximum. The long tree season, from late March to the end of June, is due to the combination of a number of different taxa flowering in succession. The grass season, mid June to the end of July, is dominated by one taxon, but with many species. Closely related species carry similar pollen allergens and individuals tend to cross-react, to varying degrees, to all species. The ragweed season, second half of August and September, is dominated by one species and begins sharply on August 14th.

2.17.2 Effects

Pollen allergy affects roughly 20 per cent of the human population. The reactions can vary from fatigue, headaches, itchy eyes, runny nose, to severe asthma. Recent studies have shown that there has been a definite increase in the number of people having difficulty with these allergens. Much of the problem is exacerbated by the effects of pollution found in cities, as it is generally thought that aeroallergens and pollution act synergistically on human health.

2.17.3 Levels

While relatively little is known about general threshold levels of aeroallergens in the atmosphere needed to invoke human responses, the most severely allergic can have reactions to very low concentrations such as 10 grains/m^3 of air. The levels of aeroallergen concentrations required to invoke responses are highly individualized and depend on the severity of the allergy to the particular allergen for each person.

In general, peak levels of pollen concentration in Metro Toronto on average are: trees - 1500-2500 grains/

m^3 of air, grass - 100 grains/m^3, ragweed - 800 grains/m^3.

2.17.4 Sources

Pollen grains are generated from plants during reproduction, hence sources of pollen follow closely the ranges of plant distribution. The common or short ragweed (Ambrosia artemisiifolia), the worst pollen allergen based on the number of people who react to it, has the epicentre of its distribution in the southern Ontario region. Also, because ragweed plants thrive in open disturbed ground, it is more prevalent in urban centres where there is a lot of construction. As a result, Metropolitan Toronto has some of the highest daily ragweed pollen concentrations in North America.

Grass pollen is large and heavy and generally disperses over much smaller distances than other pollen types. Urban and rural sources of grass pollen are high in southern Ontario, with the abundant parks and lawns providing the main source in cities and cereal crops in rural areas.

Southern Ontario lies in the transition zone between boreal forest to the north, and deciduous forest to the south. The mixed forest zone provides sources of tree pollen from many different types including some of the most allergenic such as birch, maple and oak. Metropolitan Toronto has several river systems that dissect the landscape, and these ravines provide large source areas for tree pollen within the city.

2.17.5 Monitoring

Currently in Canada, accurate pollen and spore monitoring is limited due to the labour intensive nature of the analysis. The most accurate sampling devices use a suction pump to draw a known quantity of air through an intake and impact particles on an adhesive surface. Other devices, using a rotational impaction, cause biased sampling of larger particles. In order to sense the regional airborne aeroallergen signal (and avoid very local influences), devices must be placed > 15 metres above ground and away from any obstructions to wind flow (eg rooftop abutments, other buildings, large hills etc.). Adhesives are non-water soluble and heat stable. After staining, exposed slides or tapes are examined microscopically at 2 hour intervals. Counts of the number of pollen grains or fungal spores are converted to concentrations per cubic metre of air and averaged to give an average daily concentration. Taxonomic identifications are made down to the lowest possible level.

There are two operational sites in Metropolitan Toronto, one at Sunnybrook Medical Centre and one in the east end at Scarborough Campus, University of Toronto.

2.18 METEOROLOGY AND AIR QUALITY

2.18.1 Sources and Causes of Air Pollution.

There are two causes of air pollution. The first pertains to pollution due to natural sources such as volcanic eruptions, brush fires, sandstorms etc., and is of local, regional, continental or global scale. However, it is the second type of air pollution which affects mainly industrial and urban centres, that is of international concern today. Anthropogenic emissions of contaminants into the atmosphere are also of local, regional and continental scale and are mainly the result of burning fossil fuel in industrial plants, power plants, domestic heating and in particular motor vehicles.

2.18.2 Meteorological Influences:

Weather patterns are a major influence on the air quality levels that are monitored in Ontario. Air pollution levels are affected by:

Winds- which transport and disperse pollutants from emission sourcestto receptors;

Temperature- which affects the amount of energy used and the reactions in the atmosphere;

Stability- which affects the dispersion, vertically and horizontally, of pollutants;

Precipitation- which may remove pollutants from the atmosphere;

Sunshine- which causes photochemical reactions and leads to thefformation of the contaminant called ground-level ozone.

2.18.3 Large-scale Meteorological Influences

Air quality problems such as photochemical smog (ground-level ozone) and acidic air/precipitation in Ontario are strongly linked to large-scale meteorology. In addition, stagnation periods and local accumulation of air pollutants are associated with the large scale synoptic weather patterns.

2.18.4 Stagnation Periods

In Ontario, prolonged periods of light winds are normally associated with large slow moving high pressure cells. When such situations are coupled with intense low level inversions and limited vertical mixing, “stagnation” conditions develop and air pollutants (especially suspended particulate matter) tend to build up locally. This situation typically occurs in the fall (“Indian summer” weather) and sometimes in the winter during a sudden thawing period. It can lead to undesirable air quality in the major urban centres of southern Ontario as emissions from the multitude of low level sources (cars, space heating sources, factories, etc.) are trapped near the ground for a number of days.

2.18.5 Mesoscale Meteorological Influences

In Ontario, the Great Lakes significantly influence the local surroundings. When warm southerly air masses move northward and pass over the relatively cold water of the Great Lakes, the air mass is modified, creating a condition which can strengthen the temperature inversion in the lower atmosphere. This commonly occurs in late spring and summer and often results in trapping of air pollutants and an overall deterioration in air quality.

2.18.6 Local/Microscale

On the local scale, meteorology exerts a major influence on air quality levels. Air pollutant levels are affected by winds which transport and disperse pollutants emitted from local sources; by ambient temperature which affects the amount of fuel used and the chemical reactions in the atmosphere; by the stability of the atmosphere which affects the dispersion of contaminants; by precipitation which may remove pollutants from the atmosphere; and by sunshine which causes photochemical reactions of air pollutants and leads to local formation of smog.

Topographical features, such as valleys and ridges can create local climates, which affect air quality. Stagnating air in valleys can lead to local accumulation of air contaminants. In urban areas, buildings give rise to urban canyon circulations and the trapping of pollutants locally. The nocturnal urban heat island phenomenon where night-time temperatures in cities tend to be higher than those in surrounding rural areas, results in limited vertical mixing and can lead to the build up of air pollution.

2.18.7 Summary of Meteorological Conditions (1994)

In general, the annual mean temperatures recorded at most of the weather stations in Ontario in 1994 were comparable to the temperatures in 1993 (Tables 2.18.1 and 2.18.3). However, the average daytime maximum temperatures during April were about a degree above the normal temperature for this month, while the average daytime maximum temperature during July was less than one degree below normal.

Table 2.18.2 shows that on the average, 1994 had about the same number of days as in 1993 with temperatures 30 degrees or higher, but had much less than the number in 1988. There is often a high correlation between the number of ozone exceedances of the Ontario AAQC for ozone and days with temperatures above 30°C.

During July, which is the hottest month of the year, the mean maximum temperature was 1.0°C below the normal at Sudbury, 0.7°C at London, 0.4°C at Windsor and 0.2°C at Kitchener. Toronto recorded 0.4°C above the normal during this month.

In 1994, precipitation amounts recorded at weather stations in Ontario indicate more precipitation falling in eastern sectors of the province (Table 2.18.3). During July, Sudbury recorded 74 mm of precipitation more than the normal 71 mm. Ottawa recorded 27 mm more than the normal 88 mm and Kingston 16 mm more than the normal 60 mm. On the other hand, Toronto recorded 19 mm less than the normal precipitation of 71 mm, Kitchener 7 mm less than the normal 90 mm, and Thunder Bay 8 mm less than the normal 80 mm.

The total bright sunshine hours for the majority of the weather stations in Ontario were above normal (Table 2.18.3). However, during the month of July, the sunshine hours were less than normal. For instance, London reported 85 per cent of the normal sunshine hours, Windsor 89 per cent, Ottawa 92 per cent, Sudbury 77 per cent and Thunder Bay 85 per cent. Toronto reported 102 per cent of the normal sunshine hours.

TABLE 2.18.1
Mean Temperature, Total Precipitation and Total Sunshine Hours Recorded at Selected Sites Across Ontario During 1993

Station	Annual Mean Temperature °C	Precipitation (mm)	Sunshine (h)
Windsor	9.0 (9.1)*	793 (902)	1729 (2010)
Sudbury	3.1 (3.5)	778 (872)	1805 (2059)
Ottawa	5.5 (5.8)	1043 (914)	2011 (2054)
Kingston	6.4 (6.7)	926 (964)	1906 (2012)
Toronto	7.2 (7.2)	751 (781)	1888 (2038)
Thunder Bay	1.8 (2.4)	688 (704)	1987 (2183)
Kitchener	6.3 (6.6)	797 (997)	- -
London	7.1 (7.2)	929 (955)	1590 (1858)

* Data in brackets are the normals.

TABLE 2.18.2
Number of Days With Maximum Air Temperature ≥ 30° C (1988-1994)

Station	1988	1989	1990	1991	1992	1993	1994
Windsor	52	18	13	41	2	19	17
Sudbury	21	10	0	14	0	4	4
Ottawa	23	17	15	22	6	9	9
Kingston	12	2	2	6	0	1	3
Toronto	38	12	9	21	2	11	10
Thunder Bay	15	8	3	11	2	2	-
Kitchener	29	10	2	11	1	6	8
London	30	7	1	16	0	6	7

TABLE 2.18.3
Mean Temperature, Total Precipitation and Total Sunshine Hours at Selected Sites Across Ontario During 1994

Station	Annual Mean Temperature °C	Precipitation (mm)	Sunshine (h)
Windsor	9.0 (9.1)*	875 (902)	2140 (2036)
Sudbury	3.3 (3.5)	911 (872)	1880 (2059)
Ottawa	5.6 (5.8)	945 (914)	2092 (2054)
Kingston	6.3 (6.7)	945 (964)	2069 (2012)
Toronto	7.3 (7.2)	719 (781)	2204 (2038)
Thunder Bay	2.6 (2.4)	592 (704)	2138 (2183)
Kitchener	6.4 (6.6)	827 (997)	-
London	6.9 (7.2)	874 (955)	1794 (1858)

* Data in brackets are the normals.

Section 3.0

Case Studies

This chapter of the report consists of several case studies describing air quality within the Ontario environment. It begins with a comparison of air quality levels in southern versus northern Ontario and is followed by individual case studies of problem areas in Ontario, including, air particulates in Hamilton, sulphur dioxide in Sudbury, carbon monoxide levels in Toronto, total reduced sulphur in Fort Frances, particulates in Sault Ste Marie and vehicle emissions in downtown Toronto. Other case studies include: a comparison of Toronto's air quality with air quality in selected international cities, a detailed study of the Windsor air shed and finally, results from personal exposure studies conducted in Windsor and Hamilton. The final part of the chapter briefly describes the improvement in air quality due to ministry abatement programs in various regions of the province.

3.1.1 Ambient Air Quality Comparison - Southern vs Northern Ontario

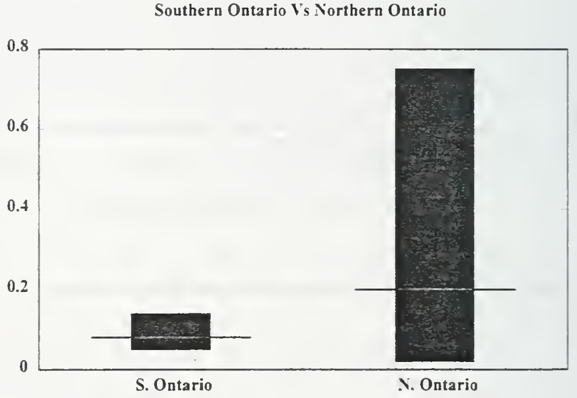
In this case study, the air quality levels at various industrial and urban centres of Ontario are discussed. Special attention is given to southern versus northern Ontario in view of the difference in the distribution of industries in these two regions. Furthermore, southern Ontario is more often affected by long range transport of pollutant species from the United States.

Ambient air concentrations for selected criteria pollutants (SO_2, CO, NO_2, O_3 and TSP) were compared for southern Ontario versus northern Ontario for 1991-1994. Data from representative monitoring sites (excluding sites which are biased by local sources) in Sudbury, North Bay, Sault Ste Marie and Thunder Bay were used to represent northern Ontario while data from representative monitoring sites (excluding sites which are influenced by local sources) in Windsor, London, Hamilton and Toronto were used to represent southern Ontario.

The range of annual means and the range of 1-hour, 8-hour and 24-hour maximum concentrations is presented in Table 3.1.1 for southern versus northern Ontario for the period 1991 to 1994. Also included in the table is the composite number of 1-hour AAQC exceedances for SO_2, CO, NO_2 and O_3 and the percentage

FIGURE 3.11

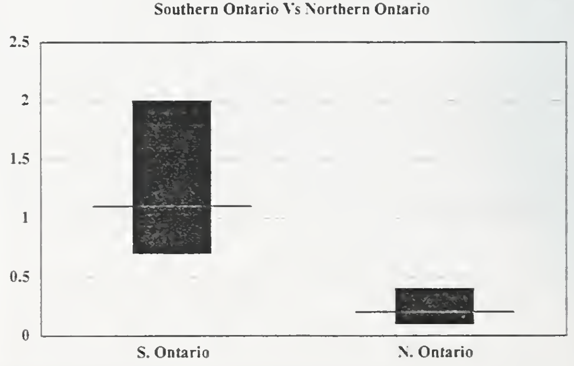
Range in 1 Hour Maxima for Sulphur Dioxide 1991-1994



Concentrations are in ppm

FIGURE 3.12

Range in Annual Means for Carbon Monoxide 1991-1994

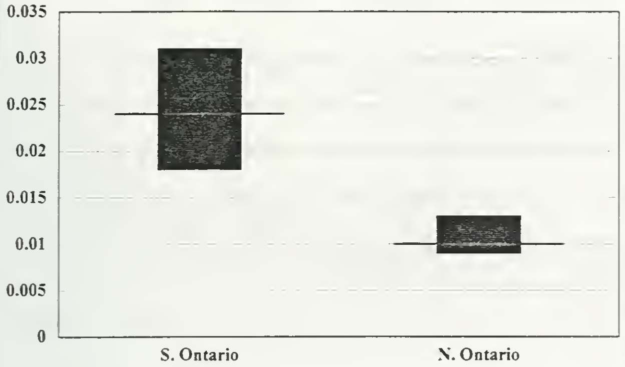


Concentrations are in ppm

FIGURE 3.13

Range in Annual Means for Nitrogen Dioxide 1991-1994

Southern Ontario Vs Northern Ontario

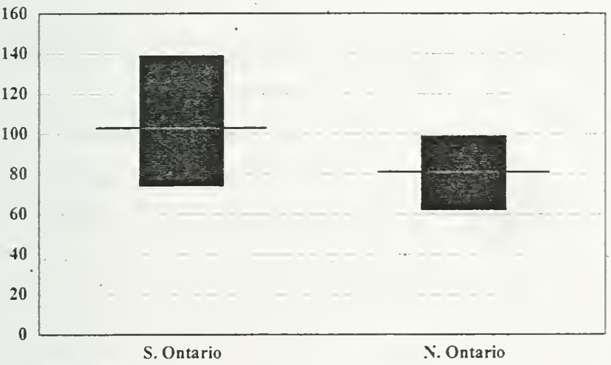


Concentrations are in ppm

FIGURE 3.14

Range in 1-Hour Maxima for Ozone 1991-1994

Southern Ontario Vs Northern Ontario



Concentrations are in ppb

of exceedances of the 24-hour TSP AAQC.

For SO_2, there is a much larger range in 1-hour maximum concentration in northern Ontario, (see Figure 3.11); and also, there were 12 exceedances of the 1-hour SO_2 AAQC recorded in northern Ontario and none recorded in southern Ontario during the period 1991 to 1994. SO_2 AAQC exceedances in northern Ontario primarily reflect the presence of the INCO and Falconbridge smelter operations for the Sudbury site. (See Section 3.1.3 for a detailed discussion of SO_2 in the Sudbury area).

For CO, the levels in southern Ontario are significantly higher. The annual means are approximately 5 times greater than the annual means in northern Ontario (see Figure 3.12). The ranges of 1-hour and 8-hour maximum values are also higher than those of northern Ontario (Table 3.1.1). Elevated carbon monoxide levels are strongly related to automobile use and emissions from combustion sources in high density urban areas.

For NO_2, the composite mean for southern Ontario is 0.024 ppm compared with 0.010 ppm for northern Ontario, (see Figure 3.13). The 24-hour maximum concentrations in southern Ontario are significantly higher than those of northern Ontario. Also, there were 6 exceedances of the 1-hour NO_2 AAQC recorded in southern Ontario (Table 3.1.1). Similar to CO elevated NO_2 levels are strongly related to the presence of high temperature combustion sources including automobiles, power plants and incinerators in high density urban areas.

For O_3, the range of annual means in northern Ontario is wider than those reported for southern Ontario. However, the opposite is true for the 1-hour and 24-hour maximum concentrations (see Figure 3.14). The composite number of exceedances of the provincial 1-hour AAQC is 320 in southern Ontario compared to 122 in northern Ontario. Long range transport is a significant contributor to elevated ozone levels across Ontario.

TSP levels in southern Ontario urban centres are significantly higher than the levels recorded in northern Ontario urban centres (see Figure 3.15). During the period 1991 to 1994, the southern Ontario composite geometric mean of TSP was 50 $\mu g/m^3$ compared to the northern Ontario composite geometric mean of 31 $\mu g/m^3$. Also the percentage of exceedances of the 24-hour AAQC for TSP and the range in 24-hour maximum values in southern Ontario were higher than that found in northern Ontario. (See Section 3.12 and 3.16 for a detailed discussion of TSP levels in Hamilton and Sault Ste Marie, respectively).

TABLE3.1.1

COMPARISON OF AIR QUALITY LEVELS IN NORTHERN ONTARIO VERSUS SOUTHERN ONTARIO, 1991-1994

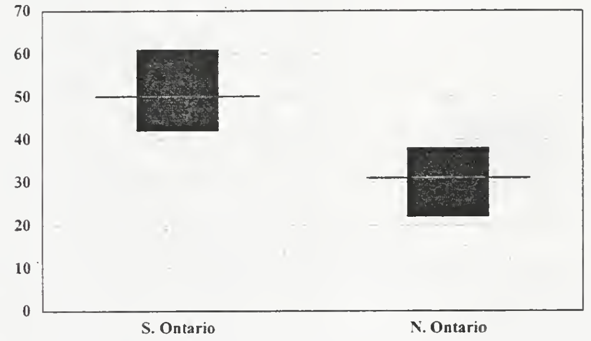
	SO_2 (ppm)		CO (ppm)		NO_2 (ppm)		O_3 (ppb)		TSP (µg/m^3)	
	South	North	South	North	South	North	South	North	South	North
Range of Annual Mean	0.003 - 0.009 (0.006)	0.000 - 0.005 (0.002)	0.7 - 2.0 (1.1)	0.1 - 0.4 (0.2)	0.018 - 0.031 (0.024)	0.009 - 0.013 (0.010)	15 - 23 (19)	18 - 26 (23)	42 - 16 (50)	22 - 38 (29)
Range of 1-h Max.	0.05 - 0.14 (0.08)	0.03- 0.75 (0.20)	6-15 (8)	4-10 (5)	0.08 - 0.26 (0.11)	0.06 - 0.16 (0.09)	74 - 139 (103)	62 - 99 (81)	N/A	N/A
Range of 8-h Max.	N/A (5)	N/A (3)	3-10	2-5	N/A	N/A	N/A	N/A	N/A	N/A
Range of 24-h Max	0.02 - 0.04 (0.03)	0.01 - 0.07 (0.03)	N/A	N/A	0.04 - 0.13 (0.06)	0.03 - 0.07 (0.04)	41 - 73 (61)	50 - 70 (54)	116 - 60 (194)	89 - 179 129)
# Exceedances	**0**	**29**	**0**	**0**	**6**	**0**	**320**	**122**	**(3.7%)**	**(1.0%)**

Figures in brackets are lhe composite mean. Geometric means are used for TSP.

FIGURE 3.15

Range in Annual Mean for Total Suspended Particulate 1991-1994

Southern Ontario Vs Northern Ontario



Concentrations are in ug/m3

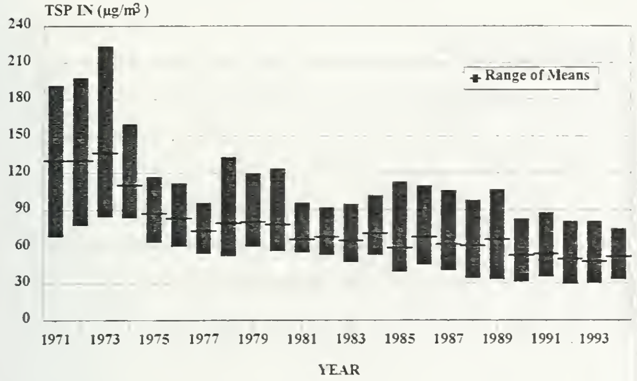
3.1.2 The Particulate Problem in Hamilton

One major air pollution problem in Hamilton has been and continues to be TSP. The average annual geometric mean TSP levels are shown to have decreased significantly over the years (Figure 3.16). There are, however, sites situated near the industrial sector along Hamilton Harbour and in the downtown core which record TSP levels in non-compliance with both the daily and annual AAQC. Since these areas are also densely populated, there is concern because this percentage of Hamilton's population is being exposed to undesirable TSP levels.

In this section, an analysis will be provided as to the time-related distribution of TSP episodes and the prevailing meteorological and climatological conditions during these events. Also, an attempt similar to the 1991 report is made to differentiate the non-attainment areas from those areas in the city which experience acceptable particulate air quality. The population exposed to undesirable levels would, ideally, provide the best measure as to the extent of the particulate problem. However, due to the limitation on the number of monitors available, the existing network does not provide a full coverage of the city to perform this type of detailed assessment. Nonetheless, an effort can be made to approximate the population exposed to undesirable levels by using the available data to generate an isopleth map and also by using these data as an indicator of particulate levels in other areas of the city with similar characteristics, where monitoring is not conducted. Isopleth mapping is a graphical technique which can be used to interpolate areas of equal concentrations from the monitoring data. The isopleth map (Figure 3.17) was generated using the average annual geometric mean TSP levels at sampling locations in Hamilton for 1991 and 1994. The isopleths for both years were drawn to scale and overlay on a map showing the neighbourhood populations in the

FIGURE 3.16

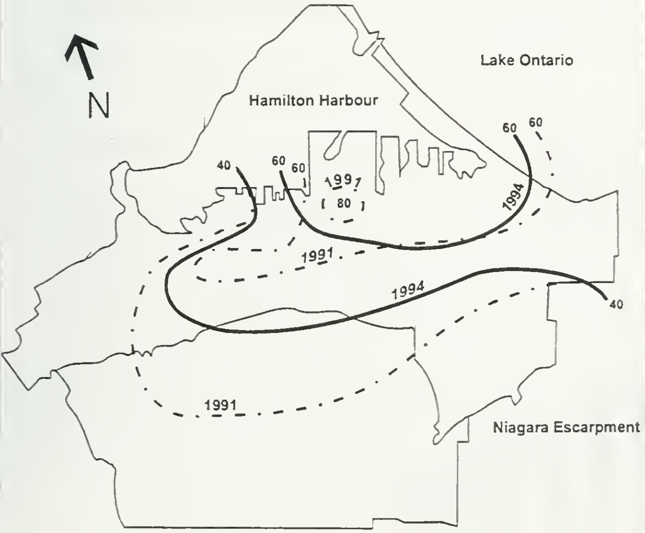
Range of Annual Mean TSP Levels at Monitoring Sites in Hamilton, 1971-1994



Note: Annual TSP AAQC = 60 µg/m3

FIGURE 3.17

Isopleth Map - Annual Mean TSP Levels in Hamilton 1991 versus 1994.



Note: TSP levels in µg/m³.

city of Hamilton for 1988 (Figure 3.18). An estimation of the population exposed to undesirable levels was determined by summing up the populations in those areas where annual mean TSP levels are observed to exceed the annual AAQC of 60 µg/m³. The results show that for 1994, a much smaller component of Hamilton's population was exposed to undesirable TSP levels compared to 1991. Again, it should be stated that due to the relatively small number of sampling sites used to generate this isopleth map, there is an uncertainty in these results. In addition, some of the monitoring stations have very localized effects, i.e., traffic influence, and therefore TSP levels may improve dramatically at short distances from the Hi-vol sampler.

As mentioned previously, the industrial complex located along Hamilton Harbour is a source of heat and pollution which affects various aspects of the local environment. The behaviour and dispersal of particulate matter is largely dependent on a combination of various meteorological processes and topographic influences.

The urban heat island effect, coupled with solar heating of the city during the day, can produce a prolonged period with a lake breeze circulation cell when winds are light. The circulation would be significantly affected by the Niagara Escarpment which can result in pollutants emitted in the Hamilton Harbour industrial centre being trapped primarily in the central and west end of the city. The city of Hamilton is an example where the Niagara escarpment combines with the lake breeze and the urban heat island to result quite frequently in extended periods of high pollutant levels particularly in the spring and fall. Local emissions can be adverted over the lower city by the lake breeze. The presence of the escarpment, along with the warmer temperatures due to the urban heat island, restrict the circulation in the lower city,

FIGURE 3.18

Hamilton Neighbourhood Populations - 1991

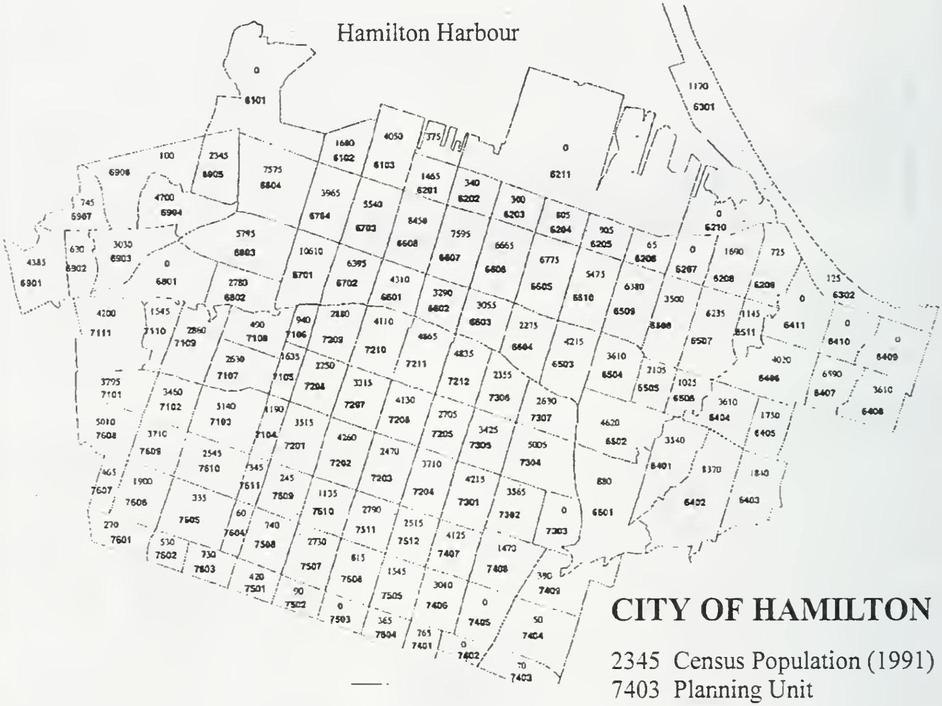
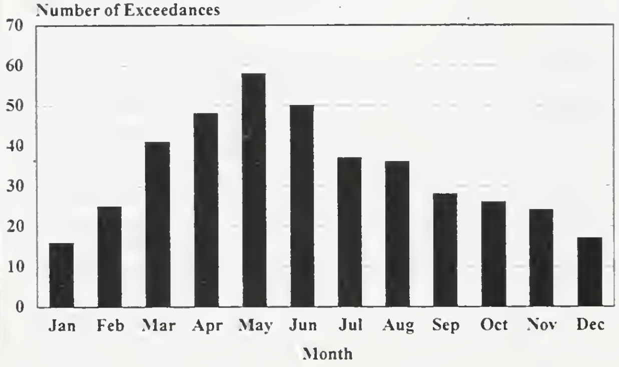


FIGURE 3.19

Monthly Distribution of TSP Exceedances at Barton/Sanford Sts. in Hamilton from 1971-1994



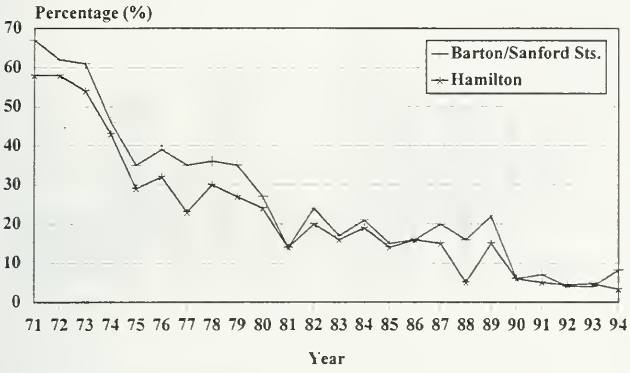
resulting in high pollutant levels there.

The number of daily TSP values exceeding the 24-hour AAQC at Barton/Sanford St. in Hamilton for the past 24 years is displayed in Figure 3.19.

This station was chosen as an example because of its extensive sampling record and also because TSP exceedances from year to year at this site generally parallel the results observed for the average of all TSP sites in Hamilton, as shown in Figure 3.20. The results are generally the same for the vast majority of monitoring sites in Hamilton and indicate that daily TSP levels exceed the AAQC more often in the spring months, with May showing the greatest frequency

FIGURE 3.20

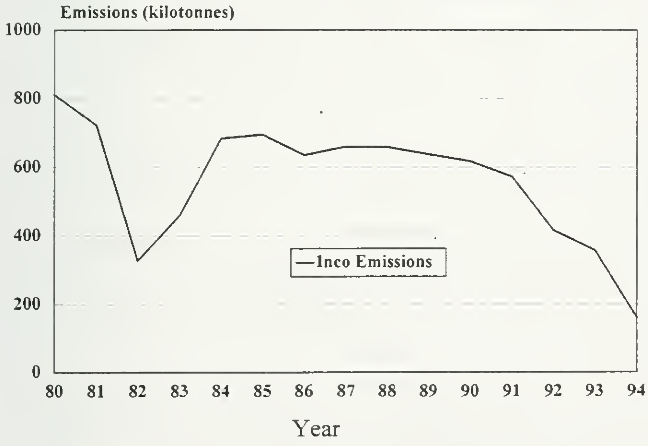
Frequency (%) of TSP Levels Above the 24-Hour AAQC at Barton/Sanford Sts. and at Sites in Hamilton



Note: Ontario 24-hour AAQC= 120 µg/m³

FIGURE 3.21

Trend in SO_2 Emissions at Inco (1980-94)



from 1971 to 1994. This is explained by changes in meteorological conditions. As the warm southerly air masses move northward and pass over the relatively cold water of the lower Great Lakes the air mass is modified, creating a condition which can strengthen the temperature inversion, thus creating poor dispersion conditions. The differential heating between the land and water is normally more prevalent during the spring months.

3.1.3 Sulphur Dioxide in Sudbury

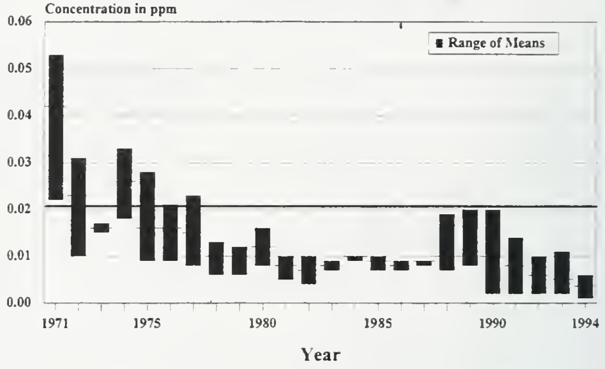
In the city of Sudbury, sulphur dioxide (SO_2) has been the contaminant of greatest concern since the Ministry began its routine monitoring in the early 1970s. The SO_2 monitoring network extends well beyond Sudbury's city limits and regional municipality to distances as far as 100 km in order to measure the impact of SO_2 emissions from the INCO and Falconbridge smelting operations. Changes in the smelting processes and emission characteristics over time have necessitated changes in the ambient SO_2 monitoring network. The majority of these changes have resulted in the relocation of several monitoring stations closer to the city limits and within the vicinity of the smelters due to the significant improvement in air quality outside of the Sudbury Region. This improvement in air quality outside the Sudbury Region is attributed largely to decreasing smelter emissions and greater dispersion due to INCO's tall stack at Copper Cliff. For example, Figure 3.21 shows that the SO_2 emissions from INCO declined by 80 per cent from 1980 to 1994. The emissions decreases around 1982 were due to economic recession and operation shut-down periods.

The objective of the extensive SO_2 monitoring program in the Sudbury area is to monitor the levels of SO_2 and to control the emissions that may adversely affect human health, animal life, sensitive vegetation and the normal use and enjoyment of property. For this purpose, ambient air quality objectives (specific to Sudbury) have been set and to achieve these objectives, sources of pollution are identified, their emissions evaluated and appropriate control measures initiated.

SO_2 emissions from the nickel and copper smelters in the Sudbury area are limited by a supplementary control program consisting of a Regulation and a Control Order. The regulation limits annual emissions according to a Federal/Provincial agreement to reduce acid rain levels, while the Control Order requires hourly average ground level concentrations of SO_2 not to exceed a prescribed limit.

FIGURE 3.22

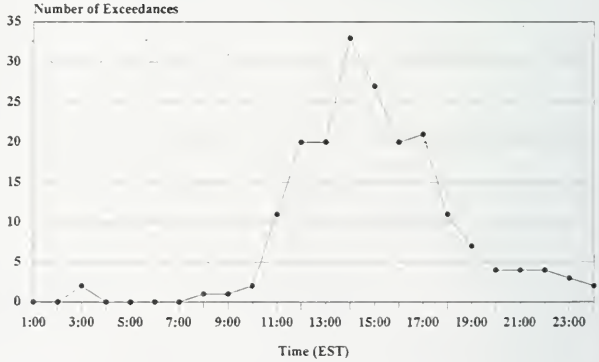
Range of Annual SO_2 Levels at Monitoring Sites in Sudbury, 1971-1994



Note: Annual SO_2 AAQC = 0.02 ppm

FIGURE 3.23

Diurnal Distribution of SO_2 1-Hour Exceedances at Science North ,1984-1994



Note: SO_2 1-Hour AAQC = 0.25 ppm

The Control Order requires the smelters to reduce SO_2 emissions through production curtailments during periods of poor atmospheric dispersion. This approach was necessary since, in spite of the use of INCO's super stack (erected in 1972), and with existing smelting processes the MOEE half-hour standard (0.30 ppm) and the hourly objective (0.25 ppm) for SO_2 cannot be met at all times due to a "looping plume phenomenon". An interim ground level concentration limit of 0.50 ppm for any 60 minute period was chosen for this program. All exceedances of the Control Order are investigated by the MOEE and charges are laid if companies are found negligent in the operation of their supplementary control program.

The graph displayed in Figure 3.22 shows the measurable improvements in the quality of Sudbury's air for SO_2 over the years. The years 1988 to 1990 show a slight increase in the composite annual mean SO_2 levels as well as a significant increase in the number of hours and days exceeding the provincial AAQC. These increases are the direct result of the "Copper Cliff" SO_2 monitoring station commissioned in 1988 to measure the impact of roof-level fugitive emissions of SO_2 from the converter aisle at the INCO Ltd. Copper Cliff smelter. The Copper Cliff station is believed to be affected mostly by fugitive emissions with little (if any) contribution from the "tall" stack.

Conversely, the monitor at the Science North complex is believed to be mostly affected by elevated SO_2 releases (stack emissions) with little (if any) contribution from fugitive emissions. However, it should be noted that in recent years (1991 to 1994) the composite annual mean SO_2 levels have continued to decrease to a value of 0.005 ppm in 1994, reflecting the success of the control strategies.

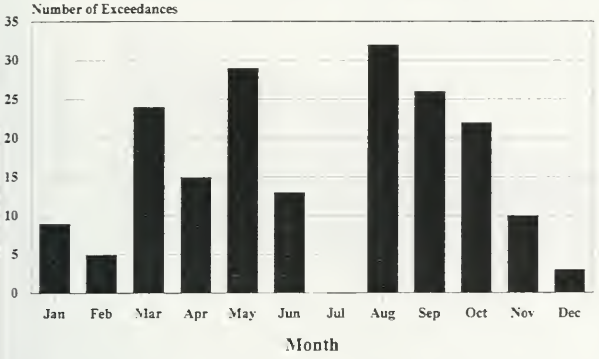
In a recent report (MOEE 1990), a correlation was attempted between INCO's SO_2 emissions in tonnes/year and the annual mean SO_2 levels for Ash Street from 1969 to 1989. The results of this regression analysis statistically showed little correlation between these two parameters. This suggests that annual mean SO_2 levels in the Sudbury area are more strongly influenced by the frequency and intensity of short-term fumigations which in turn are dependent on the year to year meteorological variability.

The purpose of INCO's tall stack erected in 1972 was to release pollutants at a greater height, thus allowing the pollutants to be carried further from the source and dispersed over a wider area, resulting in lower annual means and fewer exceedances of the provincial AAQC. Although the tall stack did not completely eliminate the problem of short-term fumigations, noticeable improvements have been observed as noted above.

Of the 180 hours which exceeded the 1-hour AAQC at the Science North station from 1984 to 1994, the majority occurred between 1200 EST

FIGURE 3.24

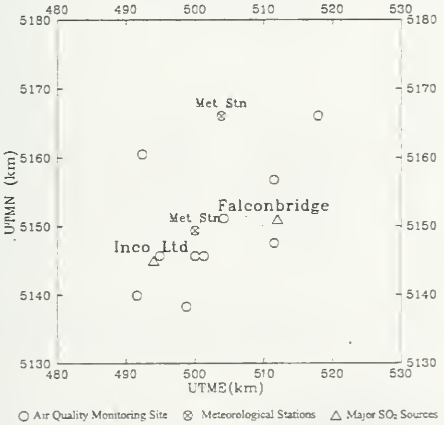
Monthly Distribution of SO_2 1-Hour Exceedances at Science North in Sudbury (1984-1994)



Note: SO_2 1-Hour AAQC is 0.25ppm

FIGURE 3.25

Air Quality Monitoring Sites, Meteorological Stations and Major SO_2 Soucres in the Sudbury Area



and 1700 EST (Figure 3.23). The meteorological data obtained from the CKNC tower in Sudbury indicate that moderate winds and/or relatively unstable conditions (as indicated by the temperature lapse rate) prevailed for approximately 70 per cent of these events. In some cases, pollutant concentrations were elevated and short-lived indicating that they were generally associated with plume looping events. The monthly distribution of these 180 exceedance hours appears in Figure 3.24. A definite pattern exists as the frequency of exceedances generally increases into the spring and summer months and decreases again with the on-set of the fall and winter. No exceedances were recorded in the months of July as smelter operations shut down for maintenance and vacation purposes.

Even though there exists an extensive network of air quality and meteorology monitoring sites in the Sudbury basin area, see Figure 3.25, for determining spatial distribution of the SO_2 data, a more realistic spatial map of SO_2 levels can best be achieved by enhancing the monitored information with a numerical model.

Here an attempt was made to estimate SO_2 concentrations on a one kilometre resolution with the help of a simplified mathematical model which incorporates emission inventory, air quality and meteorology data from the existing network of stations for a 50 km x 50 km area surrounding Sudbury. Figures 3.26 and 3.27 show the estimated annual mean SO_2 concentration isopleths (pphm) for 1990 and 1994, respectively. The spatial maps show that relatively higher levels of SO_2 lie in the sectors northeast of Falconbridge, and in the sectors southeast and northeast of INCO Ltd. The SO_2 emissions from INCO Ltd. during 1994 decreased by about 70 per cent from their levels in 1990, whereas there was approximately a 20 per cent reduction of SO_2 emissions at Falconbridge facility during the same period. As a result of these emission changes in 1994, relative peak levels appear to be slightly higher in the vicinity of Falconbridge as compared to INCO, Figures 3.26 and 3.27. Overall, a measurable improvement in air quality within the Sudbury basin area is evident between 1990 and 1994.

While long term trends have shown improvements in Sudbury's ambient SO_2 air quality, the potential for short term fumigations resulting in discomfort to people and possible injury to vegetation still exists. Up to several hundred public complaints about SO_2 are still received every year by the MOEE, mostly during the summer months. The Ontario Ministry of Environment and Energy acknowledges this problem and is working towards ensuring that INCO and Falconbridge continue to operate within the requirements of their control order and also work towards developing and implementing new control strategies and programs.

In Ontario, there are two historical examples of sulphur dioxide damage (in combination with forest fires, lumbering practices and metal emissions) at Sudbury and Wawa. The legacy of the emissions from the local mining industries is a severe loss of vegetation and a poor public image of the area, especially at Sudbury.

For over twenty years, considerable effort has been made to curtail the emissions from the smelter operations at Sudbury. This effort has greatly reduced the number of occasions during the summer growing season when the combination of SO_2 concentration and duration of a sulphur dioxide fumigation is sufficiently high to exceed specified conditions termed "Potentially Injurious Fumigations". With the improved air quality in recent years, it has been possible to revegetate much of the industrial barren land in the Sudbury area with grass and trees. Although much remains to be done in the area of emission abatement and in revegetation of the area, the land reclamation project and reduction in sulphur dioxide emissions have demonstrated that a well-organized and concentrated effort can significantly reverse environmental degradation.

FIGURE 3.26

Estimated Annual SO_2 Concentrations (pphm) in the Sudbury Area for 1990

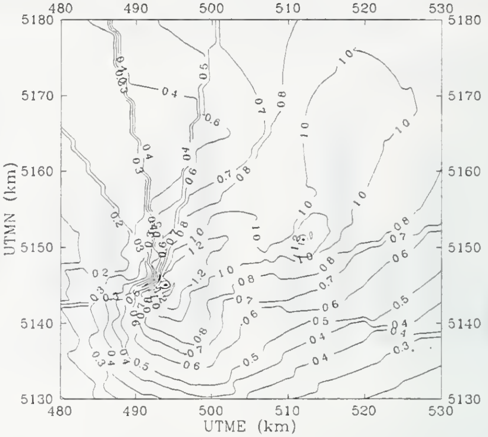
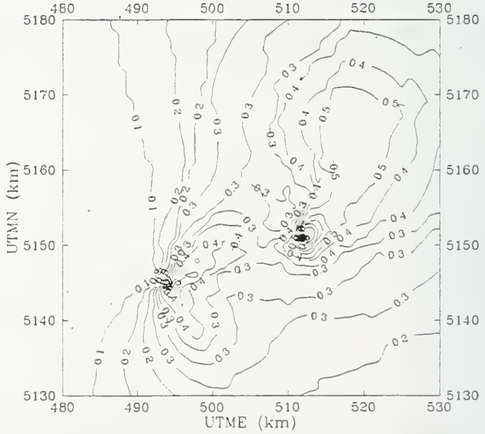


FIGURE 3.27

Estimated Annual SO_2 Concentrations (pphm) in the Sudbury Area for 1994



3.1.4 Carbon Monoxide Levels at "Mission" in Downtown Toronto

Annual mean carbon monoxide levels and frequency of violations of the provincial AAQC in the city of Toronto have shown significant improvements over the past 17 years, Figure 3.28. However, short-term levels of CO occasionally present some concern in certain areas of the city. Our attention in this case study is centred on the "Mission" monitoring station, located at 381 Yonge St., because it usually records the highest CO levels in Metropolitan Toronto as well as in Ontario. This site is also responsible for the majority of the 1-hour and 8-hour exceedances of the provincial CO AAQC.

By examining the "time" distribution pattern of elevated CO levels and relating this to several factors, including the volume of traffic, urban topographic effects and local meteorological conditions, an attempt was made to explain the reason for higher CO levels at the "Mission" site in comparison to other sites in Toronto.

The number of vehicles (volume of traffic) is considered as being one of the factors since automobile

FIGURE 3.28

Trend in Annual Mean CO Levels at the Mission Site in Toronto (1978-94)

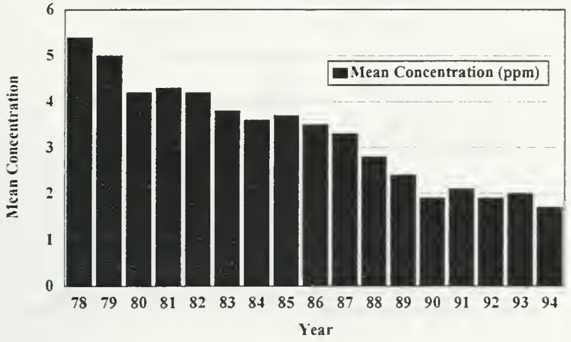
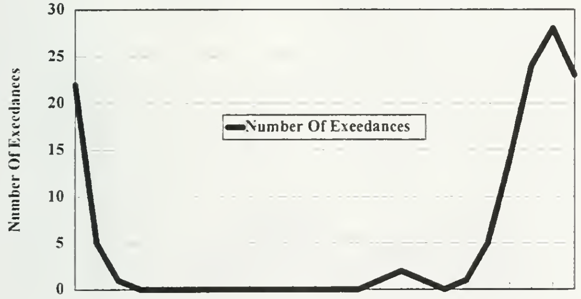


FIGURE 3.29

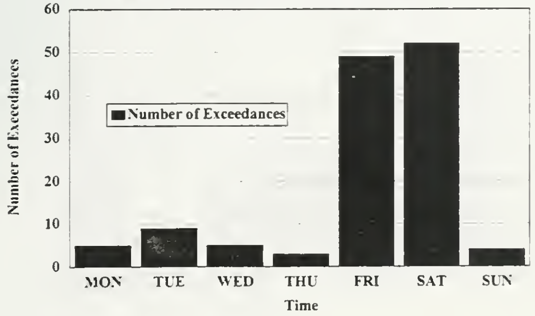
Hourly Distribution of CO Values Exceeding the 1-Hour AAQC at the Mission Site in Toronto, 1978-1994



CO 1-Hour AAQC = 30 ppm

FIGURE 3.30

Daily Distribution of CO Values Exceeding the 1-Hour AAQC at the Mission Site in Toronto, 1978-1994



*Total Exceedances - 127 *CO 1-Hour AAQC = 30 ppm

emissions are the major source of CO in large urban areas. The volume of traffic along this section of Yonge Street is considered to be heavy, especially during the morning and evening rush hours, and on weekend nights. Typical diurnal patterns of CO levels show an increase during these rush hour traffic increments. In this section, however, we are more concerned with levels of carbon monoxide which exceed the 1-hour and 8-hour provincial AAQC of 30 ppm and 13 ppm, respectively. In addition, definite patterns are also observed directly related to the time of day, day of the week, and seasonal and/or monthly distributions of these related episodes. There have been 127 hours which exceeded the 1-hour provincial AAQC at the "Mission" station from November 1977 to December 1994 with the majority occurring in the late 1970s and early 1980s. The frequency of these violations are grouped and plotted on a 24-hour time scale as shown in Figure 3.29.

The majority of these violations (87 per cent) occurred during the late-evening between 2000 EST and 0100 EST. The frequency of these episodes are also plotted versus the day of the week, as shown in Figure 3.30.

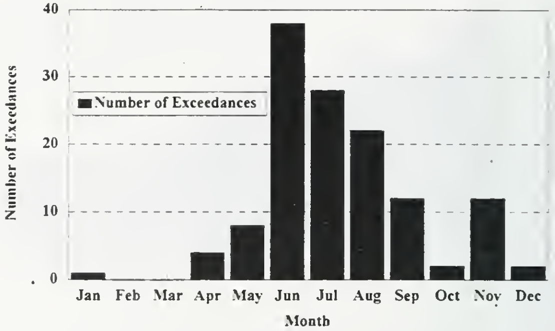
Approximately 80 per cent of these violations occur on Friday and Saturday evenings and are attributed to the heavy and steady flow of slow moving traffic along Yonge Street. The monthly distribution of these episodes displayed in Figure 3.31 also reveals a prevailing seasonal distribution of these events with the majority (69 per cent) occurring during the summer months of June, July, and August.

Now that the time we expect to observe high CO levels has been established, the prevailing meteorological conditions during these events will be examined. Since there is no available meteorological data at this site, wind speed and wind direction data at the 10 metre level from the Lawrence/Kennedy station in

Scarborough were used. The corresponding wind data with elevated CO concentrations revealed that 80 per cent of these episodes were associated with calm (<5 km/h) conditions. Light to moderate winds (5 to 10 km/h) were responsible for the remaining 20 per cent. In all of these cases the meteorological data indicate that the atmosphere was characterized as being relatively stable to very stable through the day. In a normal diurnal cycle, the change of temperature with height varies systematically through 24-hours; temperature generally decreases with height in the daytime and increases with height during the night. Typically, this cycle leads to a limited morning peak in levels of carbon monoxide because the morning accumulation of rush hour emissions is countered by increased dilution as convection destroys the nocturnal temperature inversion. In contrast, during the evening, a surface temperature inversion begins to build, hence trapping and accumulating CO as well as other vehicle related pollutants such as nitrogen oxides (NO_x) and suspended particles (COH). Historical meteorological data from the CN tower site show that the strongest temperature inversions generally occur during the night. Light surface winds and a stable stratified boundary layer are not, however, restricted to only the evening hours. On some occasions such conditions were observed during the early morning rush hour; however, they are not as predominant because solar radiation, even diffused solar radiation during overcast conditions, creates a positive radiative flux resulting in some convective activity, hence increased dispersion.

FIGURE 3.31

Monthly Distribution of CO Values Exceeding the 1-Hour AAQC at the Mission Site in Toronto, 1978-1994



CO 1-Hour AAQC = 30 ppm

The urban topographic effects also play a significant role in the behaviour of the monitored CO patterns. Building shadowing and air-flow blocking are just two ways in which large buildings and structures create a unique microclimate and mesoclimate. Studies performed in Denver, Colorado (Neff, 1990) have shown that early surface temperature inversion formation due to building shadowing in combination with other factors may contribute significantly to violations of Denver's CO standard. This situation may also occur to some extent at the "Mission" station creating unfavourable dispersion at times when the volume of traffic may be higher, allowing for an earlier accumulation of carbon monoxide. Air-flow blocking may also create calm wind conditions local to that area. If measured, wind speeds at this site may in fact be much lower on occasion compared to the meteorological data obtained from the Lawrence/Kennedy station.

The Yonge Street corridor is described by many as an "urban street canyon" which at certain times can lead to high pollutant levels. There are many areas in Toronto which have a similar urban topography and one might expect that these areas would yield higher levels of CO if measured. Although one would expect to witness improvements in air quality for CO due to more efficient and stricter emission controls on vehicles, the increasing number of vehicles on Ontario's roads today works to keep CO emissions relatively steady.

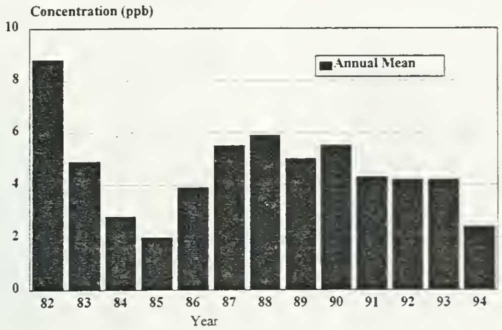
3.1.5 Total Reduced Sulphur (TRS) Odour Problems in Fort Frances

Kraft pulp mills in Ontario are major sources of TRS compounds. Odour levels from these mills have significant impact on the air quality of the surrounding community. Since its construction in the early 1970s, emissions from Rainy River Forest Products Inc., a bleached kraft pulp mill in Fort Frances, have resulted in odour problems in a nearby residential area. In the late 1970s, some emission reductions were achieved. In 1980, a Control Order was issued by the provincial Ministry for further pollution controls. The mill also created a "buffer zone" through the purchase of adjacent residential land. It should be noted that the Fort Frances situation is complicated by the presence of an additional pulp mill on the American side which is not subject to MOEE jurisdiction.

Annual mean concentration, 1-hour maximum concentration and number of exceedances of the 1-hour TRS interim standard at the main monitoring site in Fort Frances for the period 1980 to 1994 are displayed in Figures 3.32, 3.33 and 3.34 respectively. The air quality improvement apparent for 1984 and 1985 (reflected in all three figures) was due in part to

FIGURE 3.32

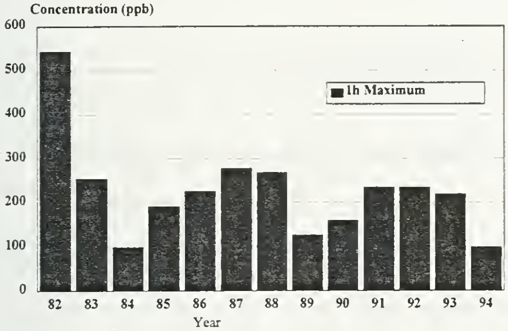
Trend in Annual Mean TRS at Fort Frances (1982-1994)



Data from stations 62030/62052

FIGURE 3.33

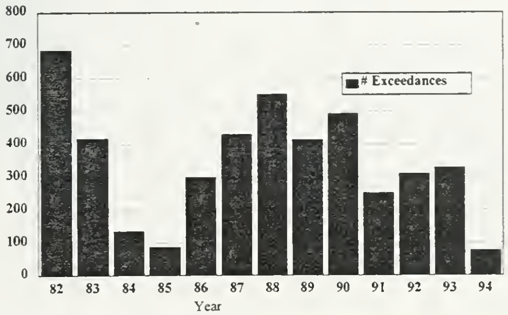
Trend in 1-Hour Maximum TRS at Fort Frances (1982-1994)



Data from stations 62030/62052

FIGURE 3.34

Trend in Exceedances of 1-Hour TRS Interim Standard at Fort Frances (1982-1994)



Data from stations 62030/62052

the use of monitors which underestimated TRS levels at that time.

The sharp decline in TRS levels from 1993 to 1994 is attributed to changes in operation of pollution control equipment at the mill site in Fort Frances. The annual mean, 1-hour maximum and number of TRS exceedances all showed significant decreases from 1993 to 1994. It is expected that the operation of a condensate stripper in early 1995 will continue to improve odour levels in Fort Frances.

Several communities in Ontario (in addition to Fort Frances) experience air quality problems due to odours from nearby kraft pulp mills. Cornwall, Thorold, Terrace Bay, Thunder Bay, Smooth Rock Falls, Red Rock and Marathon are additional examples.

It should also be noted that, on occasion, TRS 1-hour exceedances have also been recorded in Windsor, Hamilton, Oakville, Mississauga and Sault Ste. Marie. Exceedances in these locations are usually due to iron and steel or refinery operations.

3.1.6. Particulate in the West End of Sault Ste Marie

The Bonney Street (71042) site in the west end of the city is the nearest station (approximately 0.3 kilometre) to the coking operations at the Algoma Steel complex (Figure 3.35).

Monitoring at that site began in 1975 and was operated on a 6-day sampling cycle until April of 1988. In May 1988 a daily sampling frequency was put in place to better monitor trends in TSP emissions resulting from changes in the coking operations of Algoma Steel. The TSP monitoring results are presented in Table 3.12 and Figure 3.36.

Maximum 24-hour readings at Bonney Street during the 16-year period were high compared to the Land Registry Office (71049) which is located further from the Algoma plant in a commercial area of the city (Table

FIGURE 3.35

Location of Hi-Vol Monitors in the City of Sault Ste. Marie 1979 -1994

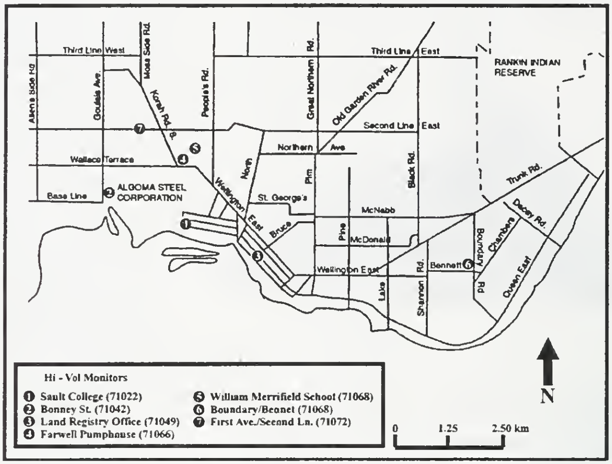


Table 3.1.2

Summary of Total Suspended Particulate data at the Land Registry Office (71049) and at Bonney St. (71042) from 1979 to 1994.

Year	Number of Samples Collected		Annual Geometric Mean (µg/m³)		Maximum 24 Hour value (µg/m³)		Number of Hourly Samples above Objective	
	71049	**71042**	**71049**	**71042**	**71049**	**71042**	**71049**	**71042**
1979	40	43	53	125	204	438	4(10%)	26(60%)
1980	40	45	62	118	222	420	5(13%)	18(40%)
1981	47	43	45	130	196	398	3(6%)	26(60%)
1982	46	49	40	100	204	476	3(7%)	20(41%)
1983	68	73	33	101	114	313	NIL	34(47%)
1984	52	51	37	96	80	386	NIL	22(43%)
1985	55	56	36	94	126	508	1(2%)	20(36%)
1986	48	53	35	74	128	344	1(2%)	15(28%)
1987	49	46	35	60	97	261	NIL	11(24%)
1988	59	267	35	79	121	388	1(2%)	96(36%)
1989	53	349	33	89	118	430	NIL	158(45%)
1990	50	341	35	55	105	460	NIL	73(21%)
1991	55	341	36	55	105	521	NIL	75(22%)
1992	114	344	29	48	114	355	NIL	44(13%)
1993	59	343	27	54	83	330	NIL	59(17%)
1994	58	211	26	62	72	311	NIL	45(21%)
Total	**893**	**2655**					**18(2%)**	**742(28%)**

Provincial objective: 24-hour = 120 µg/m³ Annual geometric mean = 60 µg/m³

( ) Percentage of samples above the objective.

3.1.2). In comparison to the Land Registry Office, the maximum 24-hour concentration range at Bonney Street was 2 to 3 times greater. The number of 24-hour measurements exceeding the annual AAQC, ranged from 13 per cent in 1992 to 60 per cent in the late 1970s and early 1980s of the total samples collected. Over the 16-year period, there were a total of 742 exceedances, representing 28 per cent of all samples collected. At Bonney Street the annual geometric mean objective (60 μg/m^3) was exceeded for 11 of the 16 years (Table 3.1.2). The highest geometric mean concentrations of 125 and 130 μg/m^3 were recorded in 1979 and 1981, respectively.

In 1987, the annual geometric mean did not exceed the provincial objective for the first time since monitoring began at that site. In the following two years, the TSP annual geometric mean values increased to 79 and 89 μg/m^3. The decreasing trend resumed for the next three years (1990 to 1992), with 1992 recording the lowest annual mean (48 μg/m^3) to date. Since 1992 the annual means have shown a slight increase, possibly due to the economic upturn shown by the corresponding increase in raw steel production at Algoma, (Figure 3.36). The success of abatement and dust control programs is evident by comparing the results of the mid-1980s with those in the early 1990s. Raw steel production levels were sustained with substantially lower TSP levels.

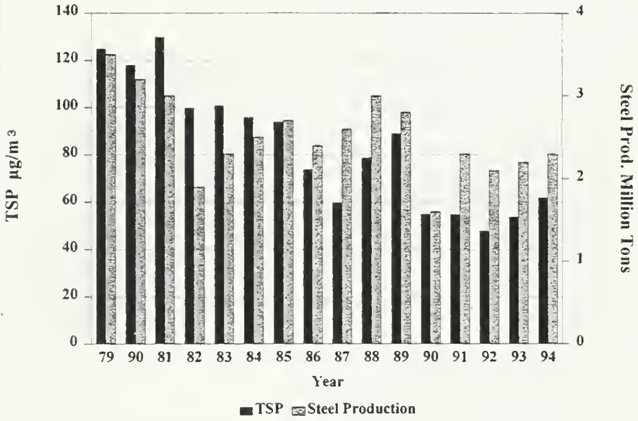
A correlation between TSP sample results and wind direction was done for the Bonney Street station. The study showed a high, positive correlation for winds from the southeastern and southern sectors.

This indicates that higher levels of TSP correlated with increased frequency of winds blowing from the these directions. Emissions from the steelworks are the major source of particulate from the southern sector. Further, negative correlations occur for winds originating from all northern sectors. These correlations show that the increased levels of particulate were not associated with winds from these directions. Similar correlation trends were found for the years in 1987 through to 1990 for TSP as well as for iron and manganese, which are constituents of particulate emissions from the steel works.

In summary, the total suspended particulate levels recorded at Bonney Street were substantially higher than at the Land Registry Office station, which is located further from the Algoma Steel plant in a downtown commercial section of the city. A large proportion of 24-hour and annual average TSP levels at Bonney Street were above their respective provincial objectives. Further correlation analysis and comparison of TSP concentrations with raw steel production shows that these elevated levels are the result of the Algoma Steel operations and the proximity of the Bonney Street site to the plant. Substantial TSP reductions have been achieved in the Bonney Stree area as a result of particulate emission control programs instituted by Algoma Steel.

FIGURE 3.36

Annual Geometric Mean TSP at Bonney St. (71042) & Algoma Raw Steel Production



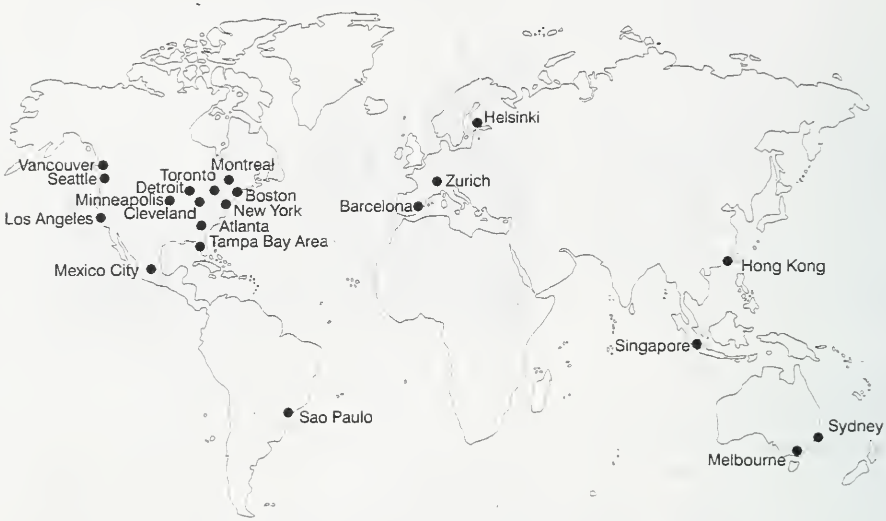
3.1.7 Ambient Air Quality Comparison of Selected Cities Around the World

Within this section of last year's annual report, five year trend data (1988-1992) for SO_2, NO_2, CO, O_3, TSP and PM_{10} were compared for fourteen selected international cities. For this year's report, we have expanded the number of cities to twenty-one, (see Figure 3.37), updated the trend data set to include six years of data (1988-1993) and added comparative statistics on the frequency of the hourly ozone exceedances at the worst site in each city's metropolitan area.

Monitoring methods and siting procedures may vary from country to country; therefore comparisons among nations are subject to caution. Since the form of air quality standards may vary from country to country, the inter-city comparisons presented here are referenced to Ambient Air Quality Criteria for Ontario (AAQC), the National Ambient Air Quality Criterion (NAAQC) for Canada and the National Ambient Air Quality Standards (NAAQS) for the United States.

FIGURE 3.37

Location of Cities Used in International Air Quality Comparison



Most of the literature comparing air quality for world cities is published or derived from the United Nations Environmental Programme (UNEP) and the World Health Organization (WHO) using data from the Global Environment Monitoring System (GEMS/AIR) network. The GEMS/AIR Monitoring Program began in 1974 and has gradually increased in size to more than 50 participating countries.

The GEMS/AIR cities are selected to provide as broad a global coverage as possible and at the same time be representative of various climatic conditions, level of development and pollution situations. In most cities there are three GEMS/AIR monitoring stations, one located in an industrial zone, one in a commercial zone and one in a residential area. It is believed that the data from these sites permit a reasonable evaluation of minimum and maximum pollutant levels and of long term trends.

In the interest of obtaining timely information on the most common air pollutants found in urban air, in early 1994, the Ontario Ministry of Environment and Energy once again, requested ambient air quality data from 29 North American and international cities. Twenty-one cities responded with air quality data which could be used in the comparison with Toronto's air quality. These cities included: Seattle, Los Angeles, Minneapolis, Cleveland, Detroit, Boston, New York, Atlanta, Tampa Bay, Mexico City, Sao Paulo, Barcelona, Helsinki, Singapore, Hong Kong, Melbourne, Sydney, Zurich, Toronto, Vancouver, and Montreal. Their metropolitan populations ranged from 0.4 million (Zurich) to 20 million (Mexico City) with the majority of the metropolitan populations exceeding 2 million.

Data from all available sites operating from 1988 to 1993 within the metropolitan areas of each city were used. It is felt that the use of all available data within the city's metropolitan area would be more representative of average city air quality than data from a select number of sites. The proximity of each monitoring site to local sources affecting air quality is not always known. For example, the Toronto data include a station in an 'urban canyon' type setting where there is high density, slow moving traffic. As a result, at this site, the levels of vehicle related pollutants are the highest in Ontario.

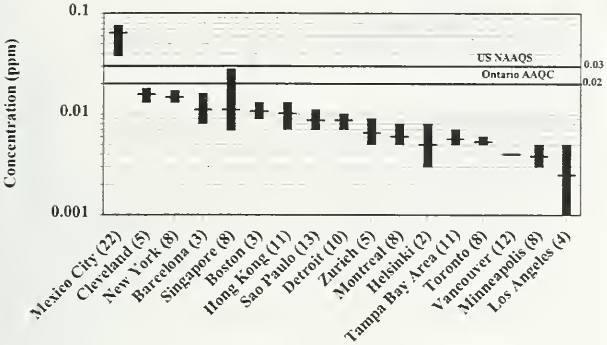
The range in composite annual SO_2 levels for 17 cities for the six year period, 1988-1993 is shown in Figure 3.38. With the exception of Mexico City, all cities were in compliance with the Ontario AAQC and the United States NAAQS standard for the SO_2 annual composite means during the period of record. It is worth noting here that there is an overall general decline in annual average SO_2 within the metropolitan areas of the majority of cities presented. Toronto was at the lower end of the range of means reported. On average, Mexico City records SO_2 levels five times greater than Toronto. During the early to mid 1970s in Toronto there was a shift to the use of cleaner burning fuels for space heating and in industry. As a result, SO_2 in Toronto during this period gradually decreased to levels well below the provincial AAQC and National Ambient Air Quality Criterion (NAAQC) during the six year study period.

The range in composite annual average levels of NO_2 for 18 cities is presented in Figure 3.39. Mexico City, New York and Sao Paulo were at the higher end of the range of annual means reported. Of the 18 cities compared, Toronto ranked eighth highest, and was the highest among the Canadian cities. Elevated NO_2 levels in the major cities are attributed to emissions from motor vehicles and thermal power plants.

The comparisons of the 6-year range in maximum 1-hour (18 cities) and maximum 8-hour (19 cities) CO concentrations are presented in Figures 3.40 and 3.41, respectively. These values represent "worst case" air quality and indicate the potential for air pollution incidents. The 1-hour United States NAAQS (35 ppm) was not exceeded in any city. However, the more restrictive (30 ppm) Ontario 1-hour AAQC was exceeded on occasion, in Sao Paulo, Minneapolis and Los Angeles. Several cities including Toronto exceeded both the US NAAQS and Ontario 8-hour

FIGURE 3.38

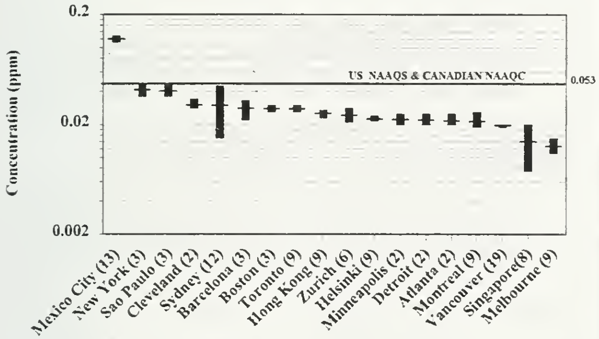
Range of Annual SO_2 Averages in Selected Cities 1988-1993



Note: Figure in brackets denotes number of monitoring sites used.

FIGURE 3.39

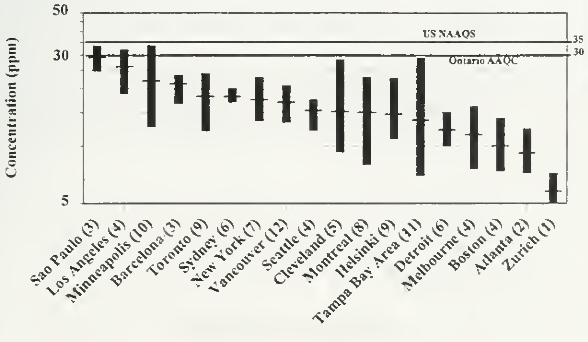
Range of Annual NO_2 Averages in Selected Cities 1988-1993



Note: Figure in brackets denotes number of monitoring sites used.

FIGURE 3.40

Range of Maximum 1-Hour CO Levels in Selected Cities 1988-1993



Note: Figure in brackets denotes number of monitoring sites used.

AAQC during the six year period of record. The Toronto data include an urban street canyon site which has much higher CO levels than any other station in Toronto. Elevated CO levels in the major cities are largely attributed to vehicle emissions, local geography and meteorology.

O_3 is a pollutant which is not directly emitted into the air, but rather, is a secondary pollutant. In Ontario, including Toronto, a major cause of elevated ozone is long range transport from outside the province. The 6-year range in maximum 1-hour O_3 levels in selected cities is shown in Figure 3.42. The 1-hour United States NAAQS and 1-hour Ontario AAQC for ozone were exceeded in all cities except Helsinki during the six year period. Of the 19 cities compared, Toronto had the ninth highest composite ozone maximum over the study period. The average number of O_3 exceedances of the 1-hour (average per year) United States NAAQS (120 ppb) are listed in Table 3.1.3 for the worst site within each city's metropolitan area.

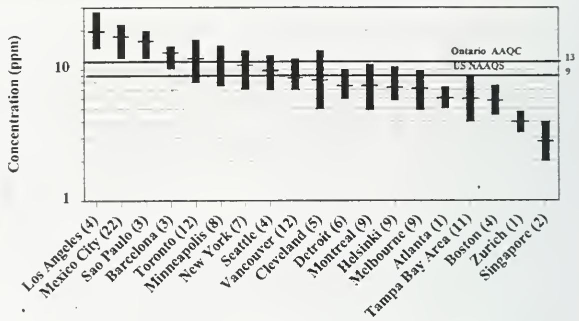
Toronto, with an average of 3 hourly ozone exceedances of 120 ppb per year, was the highest in Canada and a significant site in eastern North America for ozone excursions. This frequency, however, is 10 times lower than that of Los Angeles and probably 100 fold lower than Mexico City.

Although comparable data for Mexico City were unavailable, the severity of the problem can be seen from the average number of days of ozone exceedances of 120 ppb per year for the same time period, namely, 296 days.

TSP, a good indicator of urban air pollution problems in large cities, refers to airborne particles with a diameter between 0.1 and 100 microns. The six year range in TSP composite annual geometric means in 15 selected cities are depicted in Figure 3.43. Toronto did not exceed the annual US NAAQS or Ontario annual AAQC for TSP during the 1988-1993 period, and was near the middle of the range of

FIGURE 3 41

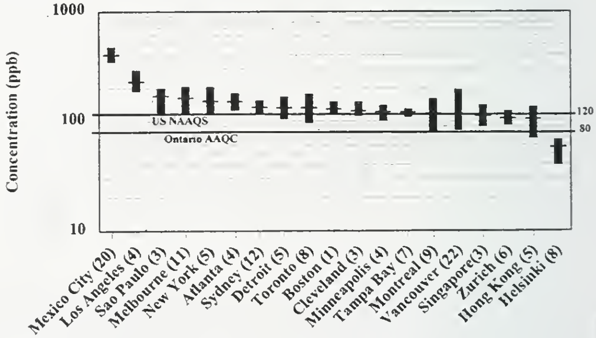
Range of Maximum 8-Hour CO Levels in Selected Cities 1988-1993



Note: Figure in brackets denotes number of monitoring sites used.

FIGURE 3 42

Range of Maximum 1-Hour O3 Levels in Selected Cities 1988-1993

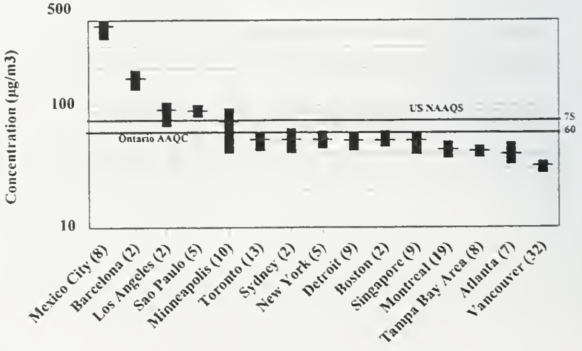


Note: Figure in brackets denotes number of monitoring sites used.

FIGURE 3 43

Range of Annual TSP Averages in Selected Cities 1988-1993

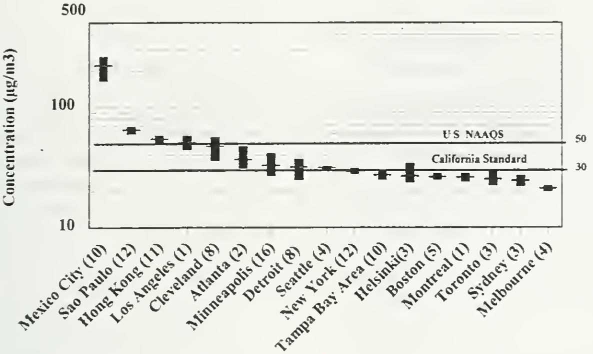
Geometric Mean



Note: Figure in brackets denotes number of monitoring sites used.

FIGURE 3 44

Range of Annual PM_{10} Averages in Selected Cities 1988-1993



Note: Figure in brackets denotes number of monitoring sites used.

TABLE 3.1.3

Average of Ozone Exceedances Per Year 1988 to 1993

City	Average Number of hours > 120 ppb	City	Average of hours >120 ppb
Atlanta	5	Minneapolis	<1
Barcelona	2	Montreal	1
Boston	<1	New York	4
Cleveland	<1	Seattle	<1
Detroit	1	Sydney	<1
Hong Kong	<1	Tampa Bay Area	<1
Los Angeles	30	Toronto	3
Melbourne	2	Vancouver	2
Note: The worst site in each city was used and the ozone exceedances were averaged over the six year period			

the 15 cities compared.

PM_{10} is that fraction of total suspended particulate comprising of particles with a diameter of 10 microns or less and has been determined to be the particle size which is most likely to be inhaled and deposited into the thoracic region of the lung. Levels of PM_{10} in Toronto were at the lower end of the range for the 17 cities reporting. Mexico City, Sao Paulo, Hong Kong and Los Angeles all exceeded the United States NAAQS annual arithmetic mean for PM_{10} during the six year period. (Figure 3.44).

The major objective of this study was to provide Ontarians with an international perspective on air quality levels for the common air pollutants in selected major cities around the world. It has been shown that the emissions from vehicles i.e., nitrogen oxides, carbon monoxide and fine particulate have a definite impact on the air quality in major urban cities and will continue to do so because of continued population and economic growth.

Over the long term, the air quality in Ontario, including Toronto, has improved significantly as a result of various abatement programs. However, ambient air quality criteria were exceeded in Toronto for ozone and carbon monoxide during the six year study period. Although PM_{10} concentrations in Toronto were found to be at the lower end of the range for cities considered in this study, because of its potential impacts on human health it remains a contaminant of concern.

3.1.8 Windsor Air Quality Study

Starting in the summer of 1991 and ending in the fall of 1993, the Ontario Ministry of Environment and Energy, in partnership with a local multi-stakeholders' group (the Windsor Air Quality Committee), conducted an intensive airborne toxics study in the Windsor area. The ultimate aim of the study was to decrease the exposure of Windsor residents to airborne toxic chemicals and involve the community in the decision-making processes for their own airshed. The two integral components of this study were scientific investigative studies and remedial action /abatement initiatives. The former component was led by the Ministry of Environment and Energy and the latter by the Windsor Air Quality Committee. It was anticipated that the scientific results would form the basis for the Windsor Air Quality Committee to develop recommendations for cost-effective remedial measures.

The scientific studies were designed to investigate the following three questions: (1) What are the airborne pollutants of concern in Windsor? (2) What is the human health risk due to exposure to these chemicals? and (3) Where and how much of these pollutants are emitted into the Windsor airshed? As a result, this effort was comprised of data collection (emissions inventory, ambient air monitoring, personal exposure assessment, and soil and crop produce studies) and the use of certain scientific tools (mathematical modelling and risk analysis) to characterize and understand the airborne toxics situation in Windsor.

Based on an International Joint Commission report on the air quality in the Detroit/Windsor - Port Huron/Sarnia Corridor (1992), the United States Environmental Protection Association's (US EPA's) Transboundary Study (1990) and the residents concern regarding emissions from the newly constructed (1986) Greater Detroit Resource Recovery Authority municipal waste incinerator, a list of over 40 airborne chemicals were initially identified to be studied as part of the scientific module. However after an initial screening and because of logistics, analytical methodologies (the compounds may have been in the airshed of Windsor but the Ministry's analytical/sampling methodologies were not sensitive enough to detect these compounds), and understanding the potential for the specific compounds to affect human health, to bioaccumulate, to persist in the environment and their toxicities, only ten of these compounds were targeted for in-depth modelling and health effects investigations. If possible, the other chemicals were also measured and the results were described in the seven technical reports comprising this Study.

The 10 target chemicals could be separated into the following four categories: metals (cadmium, hexavalent chromium and mercury); volatile organic compounds (VOCs: benzene, 1,3-butadiene, carbon tetrachloride, 1,4-dichlorobenzene and formaldehyde); polycyclic aromatic hydrocarbons (PAHs: including benzo(a)pyrene (B(a)P)); and semi-volatile organic compounds (SVOCs: specifically dioxins and furans).

In response to the first question, the pollutants of concern in the Windsor area can be characterized according to the outdoor environments, the indoor environments and smoking activities.

a) Outdoor environments:

From an emissions inventory perspective, only 6 of the 10 target compounds were identified to be present in sufficient concentrations in the Windsor airshed for which meaningful source apportionments could be undertaken. This information is summarized in Table 3.1.4.

Using the calculated estimates of potential cancer risk from long-term inhalation of outdoor air in Windsor, the following pollutants were determined to be of concern: hexavalant chromium, benzene, 1,3-butadiene, PAHs (including B(a)P), carbon tetrachloride and cadmium.

The air pollutants which may contribute to long-term non-cancer health effects were determined to be: formaldehyde, hexavelent chromium and cadmium.

b) Indoor environments:

Based on calculated estimates of cancer risks for non-smokers, the following were deemed to be of concern: 1,3-butadiene, benzene, hexavalent chromium, carbon tetrachloride, PAHs, formaldehyde, cadmium and 1,4-dichlorobenzene.

The contaminants which may pose non-cancer risks for non-smokers were: formaldehyde, carbon tetrachloride, 1,3-butadiene and hexavalent chromium.

c) Smoking activity:

Smoking will greatly increase a person's intake of benzene, 1,3-butadiene, formaldehyde, cadmium, PAHs, dioxins and furans.

In response to the second question, the health risks to the people of Windsor may be summarized as follows:

- Risks from direct outdoor air exposure are appreciably less than those from indoor air exposure.

- Smoking (including secondhand smoke) and emissions from household/office materials and personal care products contribute significantly to the risk for indoor environments.

- In general, inhalation is a more significant pathway in terms of contributing to health risks than the ingestion and dermal absorption pathways for the target compounds investigated during this study.

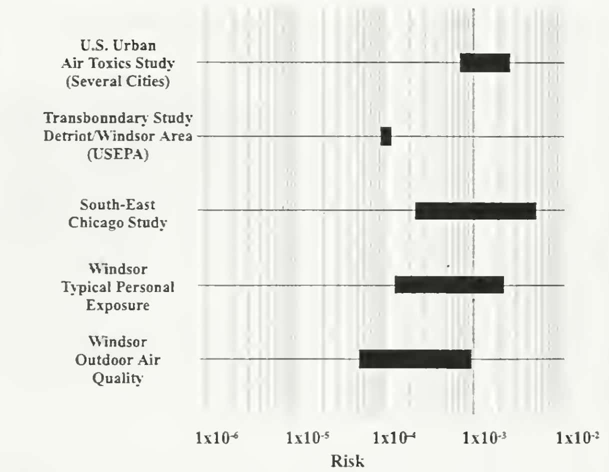
- Ingestion was identified as a major route of exposure (in terms of magnitude of intake but not contributing to health risks) for formaldehyde, cadmium, hexavelant chromium, dioxins, furans and mercury. Marginally, PAHs may contribute to health risks via the ingestion route.

- Based on existing monitoring information for dioxins and furans, the sum of exposures from all routes of entry into the human body is less than 25 per cent of the tolerable daily intake, therefore the possibility of long-term health effects in Windsor due to these compounds is unlikely. In the case of mercury, inhalation and ingestion exposures amount to, respectively, less than 10 per cent and about 50 per cent, of the applicable chronic acceptable exposure guidelines, suggesting that the possibility of long-term health risks in Windsor due to mercury is unlikely. However, because of their persistence in the environment and bioaccumulation in the food chain, efforts should continue to reduce emissions of and human exposures to dioxins, furans and mercury.

- The range of additive health risks (calculated by adding the risks for each compound) from all pollutants associated with outdoor air quality is between 5×10^{-5} and 9.4×10^{4} and is not appreciably different from those found in other US urban areas where similar evaluations were conducted (Figure 3.45). No Canadian urban airshed studies were available for this comparison.

FIGURE 3.45

Total Health Risk Associated with the Air Quality in Windsor A Comparison with Other Areas



These health risk estimates were very conservative since the concentrations used in the models and calculations were based on the reported arithmetic means and 90th percentile values for the pollutants of concern. The calculated estimates were based on a unit risk of 1 in 100,000 (i.e. 1×10^{-5}) which means that if 100,000 people were exposed to a certain concentration of a specific chemical in the air (or other medium) over their entire lifetime, one person might suffer from the adverse effect. It is a probability statement or a statement of likelihood.

In response to the third question, the sources of airborne pollutants in the Windsor area could be summarised as follows:

- Windsor's air pollutant emissions range from 82 g/yr for dioxins to 140,000 tonnes/yr for benzene. Of the pollutants included in the inventory study, about 74 per cent of Windsor's emissions are from local area sources (such as traffic, residential and commercial fuel combustion, and small industrial operations);

- Sources in Detroit and surrounding areas contribute about 58 per cent of the cadmium, 67 per cent of the B(a)P, 67 per cent of the benzene and 76 per cent of the 1,3-butadiene found in the Windsor airshed;

- Area sources, particularly vehicular and fuel combustion sources, in Windsor and Detroit, dominate the contribution to the airborne concentrations of benzene (84 per cent), 1-3-butadiene (96 per cent) and B(a)P (99 per cent) in Windsor;

- Benzo(a)pyrene, the only compound measured in Windsor that exceeds the existing Ontario air quality criterion, has about 67 per cent of its airborne concentrations originating from US sources. The remainder came from vehicles (12 per cent) and wood burning stoves (21 per cent) in the Windsor area.

It was expected that airborne B(a)P concentration levels in Windsor's airshed were higher prior to the intensive monitoring period of the Study as the coke ovens in the Detroit area were shut down for most of the Study period. However, dispersion modelling indicated very minimal contribution to ambient levels of B(a)P in Windsor from these retrofitted coke ovens which resumed operation in late 1992. However, there were insufficient air monitoring results available to confirm the modelling results of the impact of these resumed operations.

- Point sources dominate (i.e. 50 per cent from the steel industry in Detroit and 16 per cent from the automobile manufacturing sector in Windsor) the contribution to airborne chromium in Windsor.

- Road dust from Windsor and Detroit, the motor vehicle manufacturing sector in Windsor, and the steel industry in Detroit contribute 35 per cent, 27 per cent, and 13 per cent, respectively to the airborne cadmium concentrations in the Windsor area;

- Photochemical reactions and long range transport of air pollutants are responsible for most of the ground level formaldehyde in Windsor;

- Carbon tetrachloride was found to originate primarily from long range transport;

- Northwest Windsor had the highest concentrations of 1,3-butadiene and B(a)P and north-central Windsor had the highest concentrations of benzene and cadmium. These results reflecting local source contributions, primarily from the automobile manufacturing sector.

In summary, the key findings of the scientific component of the Study were: (1) health risks from direct outdoor air exposure were appreciably less than those from indoor air exposure; (2) for most of the air pollutants posing potential long-term health risk concerns in Windsor, US sources accounted for more than one-half to three-quarters of the air concentration levels in Windsor; and (3) the range of additive health risks from all pollutants associated with outdoor air quality in Windsor is not appreciably different from those found in other US urban areas where similar evaluations were conducted.

TABLE 3.1.4

Chemicals of Health Concern in Windsor: Per Cent Contribution to Air Concentrations From Various Sources*

	Cd	Cr	B[a]P	C_6H_6	C_4H_6	CH_2O**
FROM WINDSOR SOURCES						
Motor vehicle manufacturing	27	16	-	8	-	-
Steel mills and iron foundries	-	1	-	-	-	-
Mobile sources	-	2	12	17	16	7
Utilities and other fuel combustion	-	7	21	3	-	1
Other point sources	2	9	-	2	-	-
Other area sources	13	-	-	3	8	-
FROM DETROIT SOURCES						
Motor vehicle manufacturing	3	1	-	1	1	-
Steel mills and coke ovens	13	50	-	2	-	-
Mobile sources	-	-	44	31	45	7
Utilities and other fuel combustion	-	3	22	6	-	-
Other point sources	6	10	1	3	3	7
Other area sources	36	1	-	24	27	3
Total %	**100**	**100**	**100**	**100**	**100**	**25**

* Cd = cadmium; Cr = chromium; B[a]P = benzo[a]pyrene; C_6H_6 = benzene; C_4H_6 = 1,3-butadiene; CH_2O = formaldehyde.

** Photochemical reactions and long range transport of air pollutants are responsible for most of the ground level formaldehyde in Windsor, resulting in only a 25 per cent contribution from the definitive sources in Windsor and Detroit.

FIGURE 3.46

City of Toronto Carbon Monoxide Emissions by Sectors (1990)

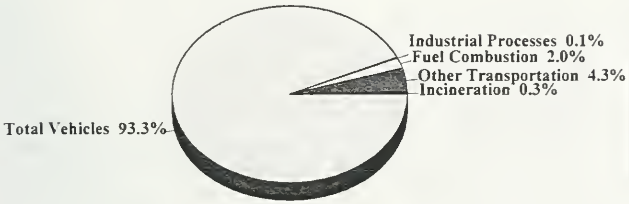


FIGURE 3.47

City of Toronto Nitrogen Oxides Emissions by Sectors (1990)

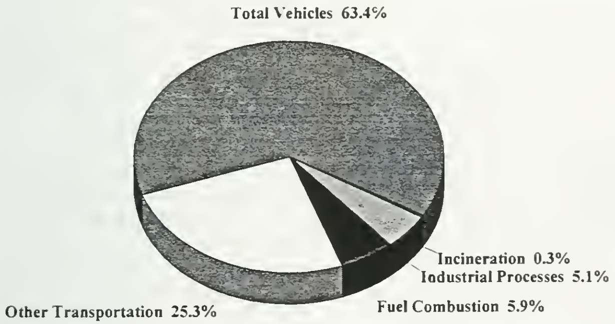
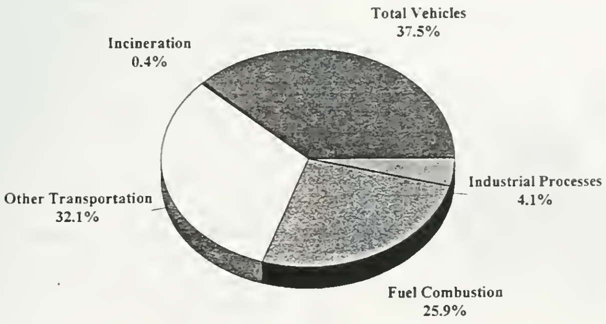


FIGURE 3.48

City of Toronto Particulate Emissions by Sectors (1990)



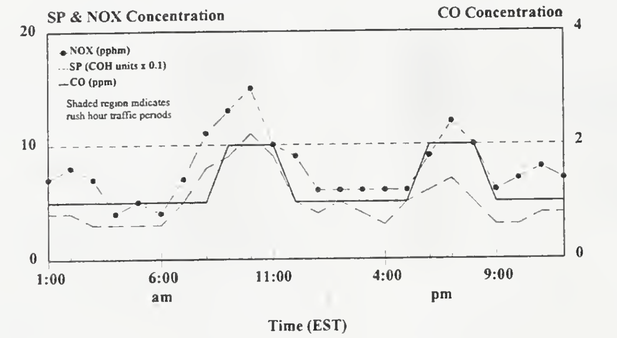
3.1.9 Impact of Vehicle Emissions on Air Quality Levels in Toronto

In the city of Toronto, vehicle emissions account for 93 per cent, 63 per cent and 38 per cent of the total emissions of carbon monoxide, nitrogen oxides, and suspended particles, respectively, (Figures 3.46, 3.47 and 3.48). This translates into approximately 132 kilotonnes of CO, 16 kilotonnes of NO_x and 0.6 kilotonnes of SP being emitted into Toronto's air annually. It is therefore, not surprising that during rush hour traffic periods within the city of Toronto. concentrations of these vehicle-related pollutants show sharp increases.t of Vehicle Emissions on Air Quality Levels in Toronto

Figure 3.49 shows the daily build up of CO, NO_x and SP at the Bay/Grosvenor monitoring site in downtown Toronto on March 7, 1994. All three pollutants behaved similarly and reached peak concentrations during the morning rush hour period, 0800 to 1100 EST. Relatively speaking, during the afternoon rush hour period, elevated levels of CO, NO_x and SP are not quite as pronounced as during the morning rush hour period. This is due to the associated meteorology which plays a significant role in determining the magnitude of these pollutants levels. The morning rush hour periods are most often characterized by light wind conditions which tend to limit vertical mixing and dispersion, resulting in the build up of pollutants levels. In the afternoon, the winds generally increase in speed which causes more mixing of the pollutants resulting in lower concentrations. This was evident on March 7th as the concentrations during the afternoon rush hour period did not reach the magnitude of the concentrations during the morning period, due to increased wind speeds which are conducive to better dispersion.

FIGURE 3 49

Daily Variation of Vehicle Related Pollutants in Downtown Toronto 7 March 1994



Note: Bay/Grosvenor monitoring site.

3.1.10 Personal Exposure Assessments

One of the basic goals of the Ministry of Environment and Energy is the understanding of the impact of airborne toxics and other contaminants on the environment and its inhabitants. A risk assessment of this impact, from a proactive perspective, is to determine a realistic estimate of the severity and likelihood of harm to human health or the environment occurring as a result of exposure to a risk agent. According to Cohrssen and Covello, this estimate consists of the following 4 distinct steps: the identification of the risk agent (or contaminant), the exposure assessment to that agent, its dose-response assessment, and its risk characterization.

Exposure assessment provides quantitative data on individuals, populations or ecosystems that are or may be exposed to a risk agent; the main elements needed are concentrations and durations of contact with the agent(s). According to Paul Lioy, personal air quality monitoring is the most direct approach for assessing human exposure to airborne agents and the next best is microenvironmental sampling accompanied by detailed time-activity information.

This method of assessing and understanding human exposure has been promoted since 1979 with the TEAM (Total Exposure Assessment Methodology) studies initiated by the US EPA. In Ontario, this approach has been undertaken in several airshed studies; more notably being the 1990 Toronto PEP (Personal Exposure Pilot) study, the 1991-93 Windsor Personal Exposure Assessment study, and the 1993 Hamilton Summer study.

It is often difficult for people to realize that they spend more time indoors than outdoors; that the indoor and personal microenvironmental air quality profiles are very similar throughout Ontario; and that a person's exposure to airborne contaminants is dominated by the air quality in these microenvironments, by personal lifestyle and habits (smoking, etc.), and by consumer products.

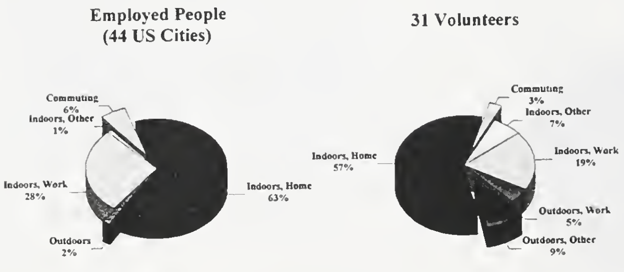
Ott et al (1988) has shown that an employed person spends more time commuting to and from work than s/he does outdoors. The time-activity pattern for the volunteers from the Windsor Air Quality Study also showed this same pattern (Figure 3.50).

The indoor microenvironmental air quality profiles for people in Windsor and Hamilton have been found to be very similar and that environmental tobacco smoke has had a very strong influence in these settings (Figures 3.51 & 3.52). The airborne concentrations measured indoors for volatile organic compounds (VOCs) were often several times higher than those measured outdoors whereas for airborne metals, the concentrations were similar or slightly less.

The importance of this approach

FIGURE 3.50

A Comparison of Time Activity Information



W.R. Ott; APCA-88-115.1 Windsor Air Quality Study to personal exposure assessment for risk analysis is shown in Figure 3.53. An assessment of personal exposure in a variety of microenvironments has shown that almost 90 per cent of a person's exposure to VOCs originates from the home or the office and that less than 5 per cent originates from outdoors.

From the Windsor Air Quality Study, the chronic carcinogenic human health risks associated with the combined impact of the selected air toxics derived solely from outdoor air quality data were estimated to range from 5.0 x 10^{-5} to 9.4 x 10^{-4}. But when personal air quality and time-activity data were taken into account, the resulting additive carcinogenic risks based on various personal exposure scenarios ranged from 1.3 x 10^{-4} to 2.2 x 10^{-3} (a two-fold increase in risk).

3.2 Documenting Selected Abatement Measures in Ontario

There are many examples in Ontario where results from abatement programs have shown improvement in air quality. Examples included here represent a range of pollution sources in various regions of Ontario.

3.2.1 Steel Mills, Hamilton

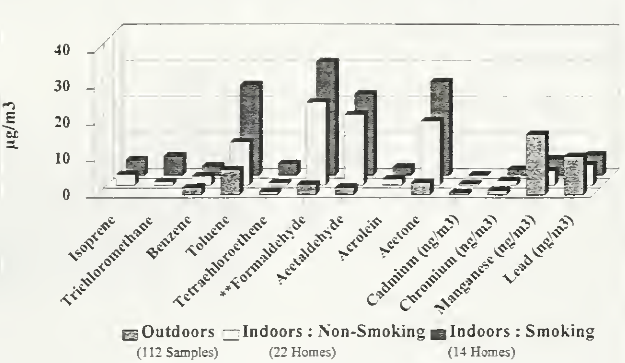
Figure 3.54 shows the correlation between particulate matter emissions from steel mills and Hamilton air quality. The graph clearly shows a steady decline in emissions from the early 1970s to the present. The resulting benefits are revealed in the trend of improvement in dustfall and TSP (total suspended particulate matter).

3.2.2 Metals Plant, Toronto

Airborne lead declined sharply near Canada Metals Co. after emissions were reduced under Control Orders issued in 1973, 1976 and

FIGURE 3.51

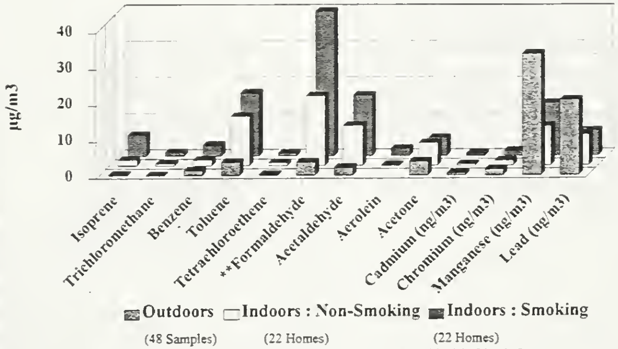
Windsor Personal Air Quality Study
Median Concentrations (at Home)



** Formaldehyde Median Concentration (Indoors:Smoking) is 31 µg/m3

FIGURE 3.52

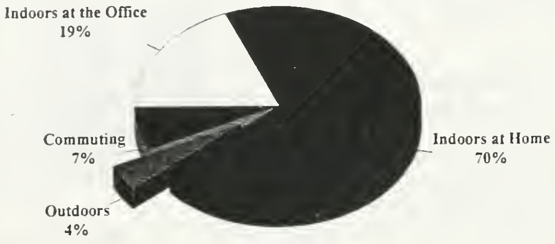
Hamilton Personal Air Quality Study
Median Concentrations (at Home)



** Formaldehyde Median Concentration (Indoors:Smoking) is 56µg/m3

FIGURE 3.53

VOC Exposure Profile
Based on Arithmetic Means - 31 Volunteers



1979, as shown in Figure 3.55. Air quality trends expressed as the annual mean airborne lead concentration and the number of exceedances of the 24-hour lead criterion, mirrored this abatement success.

3.2.3 Nickel Smelters, Sudbury

As indicated in Figure 3.56, there has been a marked decrease in "potentially injurious fumigations" (PIFs) of sulphur dioxide (SO_2) in Sudbury over the past 30 years. PIFs may cause vegetation damage. The PIF decline is attributed to reduced ground-level SO_2 resulting from a new tall stack in 1972, shutdown of one of the smelters, improved smelter process technology, Ministry Control Orders and the Countdown Acid Rain Program.

3.2.4 Pulp Mill, Dryden

Modernization of the Avenor Inc. kraft pulp mill in the early 1980s resulted in much reduced emissions of total reduced sulphur. The data in figure 3.57 document the benefit of this effort, as exceedances of the TRS interim standard declined to negligible levels.

3.2.5 Pulp Mill, Fort Frances

Fallout of "saltcake" (sodium sulphate) near the Boise Cascade Canada kraft pulp mill was the cause of many complaints from area residents. Improved process controls have reduced saltcake emissions, as confirmed by declining levels of sodium in leaves of Manitoba maple trees (Figure 3.58). Fallout complaints no longer occur.

3.2.6 Ore Concentrate Transfer site, Schreiber

There were numerous off-property dust complaints following the start-up of a transfer site A new concentrate transport system intro-

FIGURE 3 54

Particulate And Emission Trends, Hamilton, 1970-1994.

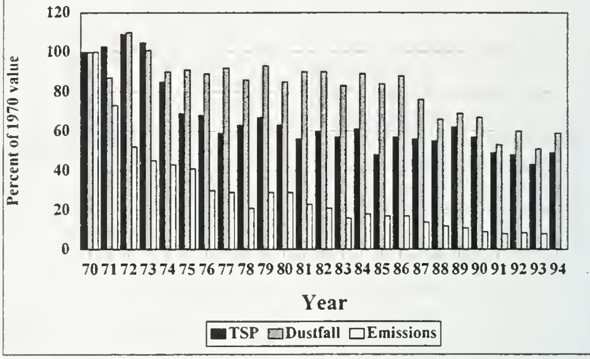


FIGURE 3.55

Lead in Suspended Particulate Matter near Canada Metals Co. Toronto, 1973-1993.

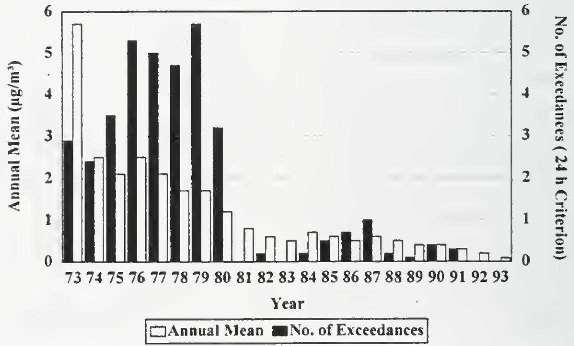


FIGURE 3.56

Total SO2 Emissions and Number of Potentially Injurious SO2 Fumigations, Sudbury, 1960-1993.

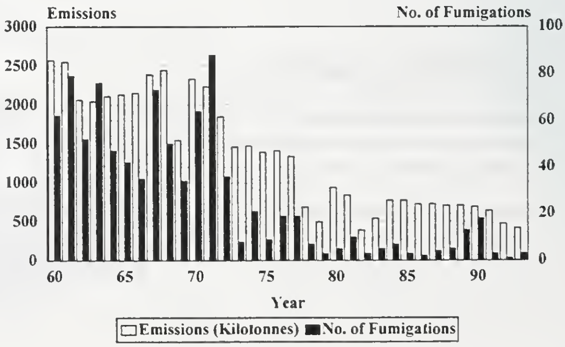
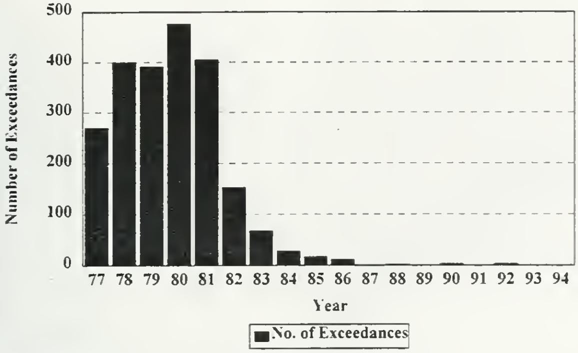


FIGURE 3.57

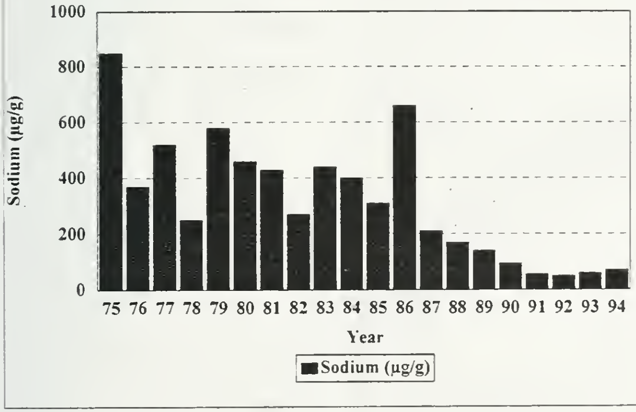
Exceedances of 1-Hour Kraft Pulp Mill Criterion for Total Reduced Sulphur, Dryden 1977-1994.



Note: 1-Hour Kraft Pulp Mill Criterion is 27ppb.

FIGURE 3.58

Average Sodium in Manitoba Maple Foliage, Fort Frances/International Falls, 1975-1994.

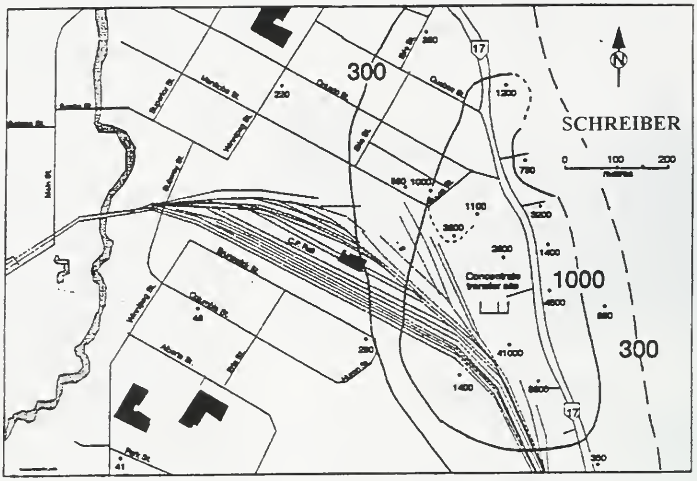


duced in 1992 resulted in greatly reduced dust emissions. Snow sampling surveys in 1991 and 1993 (Figures 3.59a and 3.59b) documented the "before" and "after" situation. There have been no dust complaints in the past two years.

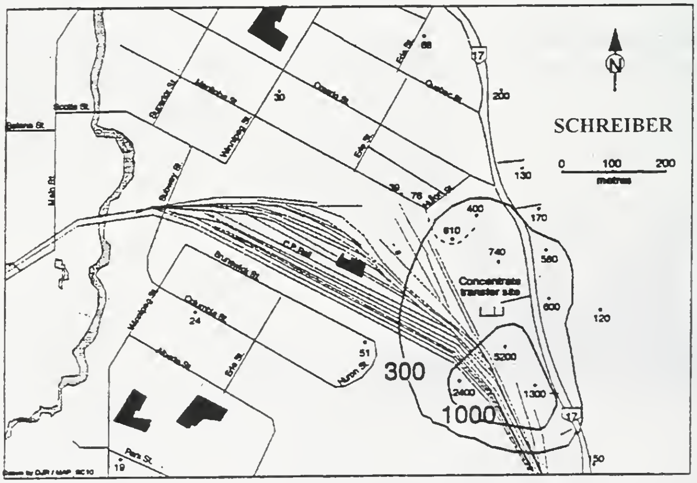
3.2.7 Steel Mill, L'Orignal

Complex scientific models were used by the ministry to show the Ivaco Rolling Mills Ltd. in L'Orignal (Eastern Ontario) that their fume control system was not operating as efficiently as it could. Even though their emissions were within the 24-hour criterion for particulates, there was a long history of complaints from residents in the adjacent community, about visible emissions, soiling and other problems. Through a voluntary Control Order, the company produced a study of the events leading to the short term fume and smoke incidents. As a result, in 1993, the efficiency of the fume control system was improved from 10 per cent to 97 per cent and an improvement in air quality was recorded.

FIGURE 3.59 a, b



a) Levels of zinc (µg/l) in snow meltwater, Schreiber, February 25-26, 1991.



b) Levels of zinc (µg/l) in snow meltwater, Schreiber, February 8, 1993.

Section 4.0
Global Issues

Increasing concentrations of trace gases in the atmosphere are of major concern and have resulted in worldwide environmental problems. In particular, two dominant effects are the build-up of "greenhouse gases" in the atmosphere and the increasing concentration of ozone depleting substances in the stratosphere. These, in turn, are related to the issues of global warming/climate change and depletion of the ozone layer, respectively. In this chapter, these issues are reviewed and discussed in the context of Ontario and some information is provided of the relevant protocols and programs that are in place.

4.1 GLOBAL WARMING/CLIMATE CHANGE

4.1.1 Introduction

The concentrations of "greenhouse gases" (carbon dioxide, methane, nitrous oxide, chlorofluorocarbons (CFCs), and ozone) are increasing in the atmosphere. Concentrations of carbon dioxide, the primary greenhouse gas, continue to rise at approximately 0.5 per cent per year. (See Figure 4.1). For methane, the increase is about 0.7 per cent per year. For the most abundant CFCs, concentrations are growing less rapidly, largely due to the effects of measures taken under the Montreal Protocol.

In the lower regions of the stratosphere (about 20 km altitude), ozone has a strong greenhouse effect, and rates of its decrease of up to 1.5 to 3 per cent per year have been noted in some regions. There is also evidence for increasing concentrations of ozone in the lower atmosphere (approximately below 15 km) of the northern hemisphere. The net effects in total changes in atmospheric ozone are as yet uncertain.

In some industrialized regions in the northern hemisphere sulphate aerosols have reached concentrations of more than 25 times natural levels. It is believed that the resultant cooling effects may have offset global warming influences of past increases in greenhouse gas concentrations by 25 to 50 per cent.

In addition, reductions in stratospheric ozone attributed to CFC emissions may have largely offset most of the global warming effects of CFCs. However, changes in ozone concentrations in the lower atmosphere may be adding to the greenhouse warming effect.

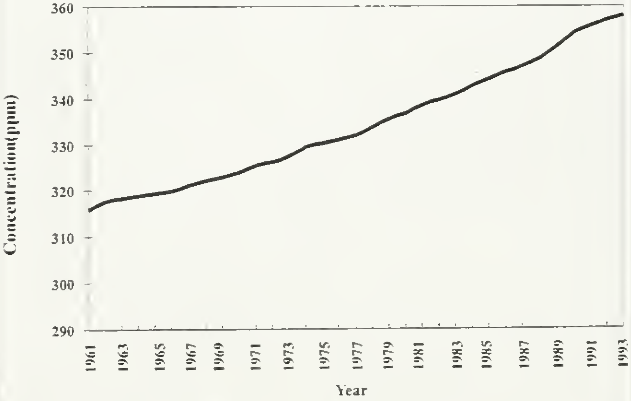
Best estimates suggest that these increases will cause world temperatures to increase by 0.2 to 0.5°C per decade.

As these gases help to regulate the earth's temperature by trapping the heat released from the earth's surface, their steadily increasing concentrations (due to human activity) are of serious concern, posing a threat to the world's climate and human life. Global warming/climate change is one the most complex and perplexing environmental issues of the present age.

Based on model predictions, future warming can significantly alter many important climatic features of the world including that of Ontario. Ontario's agriculture, forestry and energy (hydro-electricity) sectors may

FIGURE 4.1

Trend of Atmospheric Carbon Dioxide Concentrations 1961-1993



Note: Observations from Mauna Loa, Hawaii.

Soucre: Environment Canada

all be significantly impacted. The entire ecosystem could be altered as the range and distribution of plant and animal species change. Many potential aquatic consequences may occur, e.g. wetland disappearances, water supply decreases, bio-diversity loss and fish habitat effects. Economically, the costs to society could be enormous.

Despite the sophisticated computer models that have been developed, a great deal of uncertainty remains over the precise amount of global warming we can expect because of feedback effects. Most notably are the effects of oceans, ocean currents and clouds. Moreover, the uncertainty surrounding the actual impacts is even greater than that surrounding the predicted degree of global warming, partly because the relationship between climate and other systems such as lakes and forests is not completely understood, and partly because the computer models cannot predict regional changes with any reliability.

4.1.2 Indicators

Greenhouse Gas Emissions in Ontario

The major anthropogenic "greenhouse gas" emissions in Ontario are:

Carbon dioxide - Emitted by sources related to human activity, such as the burning of fossil fuel for energy, for transportation, industrial production, electric power generation and heating. (Figure 4.2). Approximately 160 million tonnes are emitted yearly in Ontario from the above sources.

Methane - Produced from organic matter decaying in the absence of oxygen such as emissions from landfills. Approximately two-thirds of the nearly 1.1 million tonnes emitted yearly are from landfills. The digestive systems of cattle also produce large amounts of this greenhouse gas.

Nitrous oxide - Emissions from human activity in the province are about 31,000 tonnes in 1990, of this 55 per cent was from the production of nylon. Significant reductions in this source are anticipated by the end of the decade. Other sources include chemical fertilizers and the burning of fossil fuels. Nitrous oxide is also produced naturally by microbes in the soil and bodies of water.

Chlorofluorocarbons(CFCs) and their substitute, **hydrochlorofluorocarbons (HCFCs)** and other related chemicals generated by human activity are also potent greenhouse gases but their concentrations are low in the atmosphere.

4.1.3 Global Atmospheric Concentrations

From 1984 to 1993, carbon dioxide levels increased by approximately 3.5 per cent. Concentrations in the atmosphere were more than 28 per cent higher in 1993 than in pre-industrial times.

Methane increased by about 5.6 per cent between 1983 and 1993

FIGURE 4.2

Ontario Carbon Dioxide Emission Sources 1993

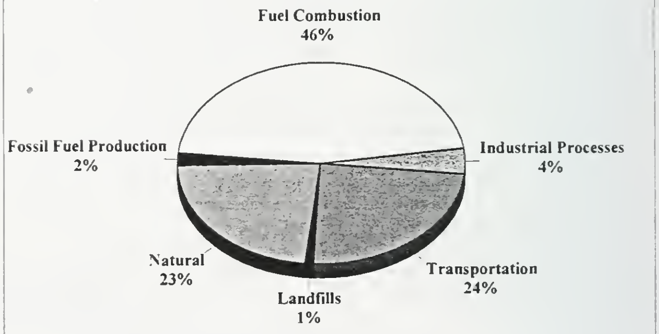
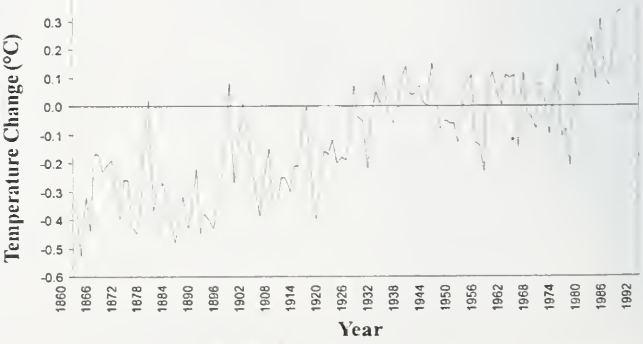


FIGURE 4.3

Global Surface Temperature Trend 1861 - 1992



Source: Environment Canada

while nitrous oxide rose by about 3.7 per cent.

4.1.4 Global, Canadian and Ontario Average Temperatures

Average global temperatures have increased approximately 0.5°C since 1895 (Figure 4.3). Canada's mean temperature increased by about 0.9°C between 1895 and 1993.

In northern Ontario, the temperature increase since 1890 has been the same as the global average. But in southern Ontario, it has been slightly more, approximately 0.6°C. Whether such observations reflect global warming or natural climate variability need to be resolved.

4.1.5 Air Quality Implications

In Ontario, the impact of climate change (on air quality) could lead to increased emissions of ozone precursors and increased photochemical activity, leading to more severe ozone episodes. Predicted changes to the global air circulation pattern may also result in more episodes of elevated ground-level ozone in Ontario. There is, in addition, the potential of increased suspended particulate levels (dust) in areas where warmer and drier conditions are forecast.

Global warming could also have an impact on acid rain, both regionally and globally. It has been suggested that this would exacerbate the already serious effects of acid rain.

The interactions between climate change and environmental problems contain many uncertainties. For example, there are other implications to the acidification issue. Sulphur dioxide emissions have a direct effect on radiation absorption via the aerosol route and an indirect effect via cloud formation. Acid deposition may lead to significant formation of nitrates in soil, thereby reducing methane decomposition capacity and increasing nitrous oxide production. Nitrogen deposition may also lead to higher biomass production in the oceans. Air quality (reflecting the composition of the atmosphere), climate and ecosystems are thus all inter-related. Indeed, changes in air quality (e.g. ozone and precursors, anthropogenic aerosols, etc.) can have potentially important roles in climate forcing and hence, on global warming.

The potential effects of climate change on human health are far-reaching. It includes increased heat-related mortality in large cities that come under the influence of hot humid air masses (e.g. Toronto and Ottawa). For example, using two General Circulation Model-based scenarios, it was found that Montreal mortality rates could be twenty times that of today. Other potential health consequences include the (re-) introduction of vector-borne diseases, increased exposure to moulds and pollens and increased risk of dehydration.

4.1.6 Current Status

Current general circulation models used to predict climate change need to be improved. More confidence is needed on how great the warming will be, how it will affect temperature, precipitation, evaporation, soil moisture and other important climatic features on a regional scale. There is also a need to gain more certainty about when these changes will take place.

To reduce uncertainties, a number of modelling improvements are being addressed such as the treatment of clouds, representation of soil and vegetation characteristics, treatment of chemical interactions involving trace gases such as sulphur dioxide, ozone and carbon dioxide in the middle atmosphere, the inclusion of a three-dimensional, fully circulating, interacting ocean.

4.1.7 Protocols and Programs

To begin to address the significance of climate change, over 100 countries by December 1994 (including Canada) have adopted the United Nation Framework Convention on Climate Change. This agreement requires developed countries to take actions aimed at stabilizing net emission of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol at 1990 levels by the year 2000.

Canada

Canada is committed to the aim of the Framework Convention on Climate Change. A National Action Program on Climate Change (NAPCC) was drafted in 1994 which is designed to enable Canada to meet its greenhouse gas emission reduction targets. All indications are that the reduction of greenhouse gas emissions will require action by all sectors of the Canadian economy.

Ontario

Internationally, greenhouse gas emissions will certainly increase over the next decade. Ontario's emissions are currently forecast to increase by about 8 per cent by the year 2000 (based on a baseline emissions of 1990) unless further measures are taken.

Ontario already has in place a significant number of measures that will achieve reduction/stabilization of greenhouse gas emissions. Key measures to achieve emission reductions/stabilization include industrial efficiency indicators, vehicle inspection and maintenance, renewable energy initiatives and energy efficiency standards for appliances and equipment. Without these measures, emissions in Ontario would be about 20 per cent above 1990 levels by the year 2000.

4.2 STRATOSPHERIC OZONE

4.2.1 Introduction

Ozone, a naturally occurring trace gas through the atmosphere, is most abundant at an altitude of 20 to 50 km where it forms the stratospheric ozone layer.

This layer of ozone acts as a protective shield for life on earth by absorbing the sun's harmful ultraviolet rays before they reach the earth's surface. It also plays a critical role in determining the patterns of the world's climate.

The thickness of the ozone layer can be temporarily affected by natural factors such as unusual weather conditions, volcanic eruptions and wind patterns in the upper atmosphere.

Concern about stratospheric ozone depletion which began in the early 1970s, continues to be a concern. Over the middle latitudes of North America it appears that the layer has been thinning at a rate of 4 to 6 percent per decade. Stratospheric ozone depletion has been linked to the action of a number of manufactured chlorine and bromine compounds. Their long lifetimes allow these compounds to penetrate into the stratosphere, where they eventually break down, releasing ozone-depleting chlorine and bromine.

Stratospheric ozone depletion has been linked to increased levels of ultraviolet-B (UV-B) radiation at ground level. Potentially deleterious effects of increased UV-B radiation include the increased risk of skin cancer in humans, and damage to crops and forests, and disruption to the marine food chains.

4.2.2 Indicators

4.2.2 a New Supplies of Ozone Depleting Substances (ODS)

New Canadian supplies of known ozone-depleting substances fell from its high point of 27.8 kilotonnes in 1987 to 5.8 kilotonnes in 1993, under the influence of the Montreal Protocol. Ontario's consumption is estimated at 40 per cent of Canada's total.

The list of ozone depleting substances includes: chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, hydrochlorofluorocarbons (HCFCs) and methyl bromide.

The manufacture of CFCs in Canada ceased in early 1993. Until the January 1, 1996 phase out, any new supplies of CFCs in Canada will be imported. In 1993, new Canadian supplies of CFCs were less than 1 per cent of the global production.

4. 2.2 b Atmospheric Concentrations of Ozone-Depleting Substances

Global atmospheric concentrations of CFC-11 and CFC-12 (the dominant ODS) have increased steadily since measurement began in 1977. However, growth rates have decreased significantly since 1989.

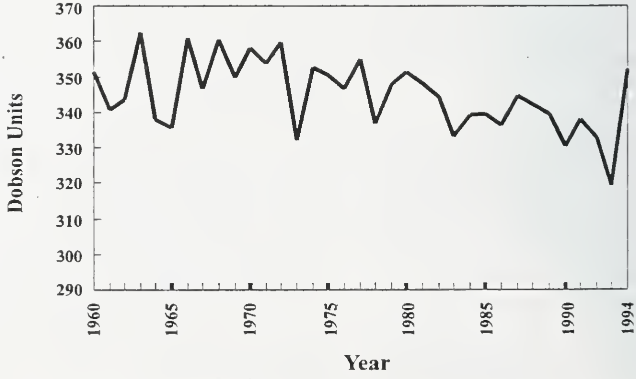
Recent information siggests that the reservoir of CFCs will persist in the atmosphere for up to 50 years. Thus, CFCs will continue to cause stratospheric ozone depletion long after production has ceased.

4.2.2 c Stratospheric Ozone Levels

Since 1979, there has been a steady decrease in the amount of stratospheric ozone over the entire globe, a 4 to 6 per cent decrease per decade in mid-latitudes, and a 10-12 per cent decrease per decade in higher latitudes. Global ozone levels are returning to values closer to those expected from the longer-term downward trend, reflecting a global recovery from the effect of Mount Pinatubo eruption in June 1991.

For the first nine months of 1994, total ozone levels over Toronto were still 3.7 per cent below the pre-1980 levels. Figure 4.4 shows the total ozone levels over Toronto for

FIGURE 4.4
Concentration of Stratospheric Ozone over Toronto 1960 - 1994



Source: Environment Canada

the period 1966 to 1994.

4.2.3 Impacts

Ecological impacts of ultra-violet radiation (UV-B) could be critical and may be wide-spread. Sensitive species may be at risk of extinction and decline in species richness and abundance is possible and may be accompanied by a loss in range for other species. Adverse effects include foliar damage, decreased aquatic primary (food chain) production and accompanying changes to the nutrient pool. Adverse economic impacts of ultra-violet radiation include reduced and/or damaged resource values, crop yields, decline and damage to property.

UV-B is associated with critical, serious, adverse and minor health impacts. Critical impacts include increased incidence of malignant melanomas and other skin cancers often resulting in death or reduced lifespan. Serious effects like the development of cataracts also occur. In addition, impaired natural body functions (i.e., immune system suppression) have less direct consequences. Actions to avoid risk and nuisance effects like sunburn lead to lifestyle changes and mental distress. This spectrum of potential health impacts can thus have corresponding socioeconomic implications.

Minor socioeconomic impacts are focused on the quality of life and adaption to the increased risk of outdoor activities.

4.2.4 Current Status

In 1994 the ozone layer over Canada recovered from the record low levels of 1993. [This, however, was short-lived as the ozone layer thickness in the winter/spring of 1995 dropped again to approach the low values of 1993].

Depletion of the stratospheric ozone layer and increased levels of ultraviolet radiation at ground level continue to be a concern today and indeed will be of concern in the foreseeable future. All evidence suggest that recovery of the ozone layer is unlikely to be completed until the mid-twenty-first century at the earliest.

Programs are currently in place which are focused on the quality of life and adaptation to the increased risk of outdoor activities in Canada, including Ontario. Daily forecasts of the UV-B index, which reflects the intensity of UV reaching the ground, are provided for various locations in Ontario by Environment Canada. For example, Figure 4.5 shows the seasonal changes in maximum UV Index in southern Ontario with time of day. At levels between 4 and 6.9 (moderate), precautions are advised to limit UV exposure. At 7 and above (high), burns and skin damage can occur quickly. As well, "ozone watch" reports weekly information to the public on the state of the ozone layer over Canada, including Ontario.

4.2.5 Protocols and Programs

International Level

The Montreal Protocol of 1987 and subsequent amendments (ratified by more than 130 countries) established timetables for phasing out the consumption of the major ozone depleting substances.

Agreement has been reached to accelerate the phase out of the new supplies of ozone depleting substances. Consumption of CFCs, carbon tetrachloride and methyl chloroform will now cease by January 1, 1996. Consumption of halons was phased out by January 1, 1994. Less damaging substitutes, mainly HCFCs are being introduced to replace CFCs. HCFCs, in turn, will be phased out by the year 2030. Developing countries have been granted an additional 10 years to reach most of these phase out targets.

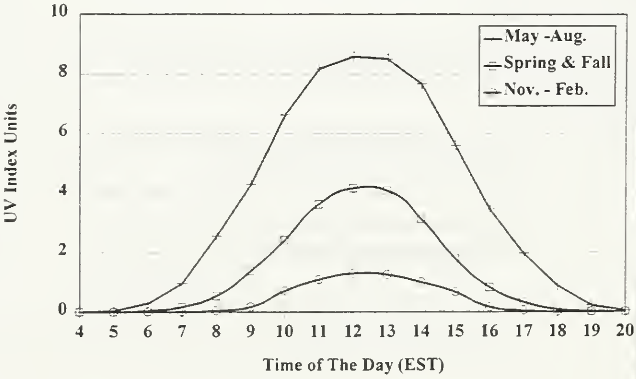
Methyl bromide, a pesticide and soil fumigant, is now recognized by the scientific community as a contributor to ozone depletion. Agreement has been reached to freeze consumption at 1991 levels by January 1, 1995. Moreover, Canada has already announced a further 25 per cent reduction by 1998.

Federal/Provincial Level

Federal legislation regulates the consumption (production plus imports minus exports) of ozone depleting substances. Nine provinces

FIGURE 4.5

Seasonal Changes in UV in Southern Ontario



Source: Environment Canada

have regulations designed to prevent and reduce emissions of ODS. In seven provinces, refrigeration and air conditioning technicians must take a training course that sensitizes them to the stratospheric ozone issue and enables them to identify and adopt good practices in their every day work. This course is based on the Canadian Environmental Protection Act (CEPA) Code of Practice.

Ontario has introduced regulations banning the use of CFCs and HCFCs in new motor vehicle air conditioners, beginning with the 1996 model year. The regulations would also prevent the venting of CFCs and HCFCs and hydrofluorocarbons into the atmosphere. In addition, anyone servicing refrigeration equipment containing fluorocarbons will have to complete a brief training course and be certified by the province.

Ontario's Ozone-Depleting Substances Program

Ontario was the first province to regulate the use of ozone depleting substances in the manufacturing of foams and aerosols. The use of these substances as refrigerants, halons in fire extinguishers, solvents and sterilants was regulated in 1994. As a result, Ontario has the most comprehensive ODS program in Canada with regulations controlling almost 98 per cent of their use. The ministry is participating in a national working group lead by Environment Canada on the future of methyl bromide.

4.3 NO_x/VOC/TROPOSPHERIC OZONE

There are several regulations, programs, policies, agencies and accords at the various ministry, provincial, federal, and international levels which are addressing the ground-level ozone issue. The following is a list of these initiatives by jurisdiction:

International Level

At the international level, the ozone issue is being addressed through the Canada/US Air Quality Accord, NO_x/VOC Protocols and International Joint Commission (IJC).

Federal/Provincial Level

The federal/provincial governments have been working together on several joint programs to limit the emissions of NO_x and VOC. These programs include:

- **NO_x/VOC Management Plan which is a nation-wide ground-level ozone reduction effort;**
- **More stringent NO_x standard for 1994-1996 motor vehicles (a federal initiative);**
- **Air Quality Advisory which encourages the public to practise pollution prevention during periods of forecasted elevated levels of ozone.**

Ontario

As part of its approach to controlling smog, Ontario has introduced a number of initiatives to reduce ozone and its precursor emissions of NO_x and VOCs. These initiatives include:

- a Gasoline Volatility Regulation which restricts the volatility of gasoline during the summer months;
- a Stage I Vapour Recovery Regulation which helps to reduce VOC emissions during the transfer of gasoline;
- transit, building code and taxation initiatives to reduce energy use and energy-related emissions;
- a Dry Cleaning Training Regulation;
- a Stationary Combustion Turbine Engine Policy on NO_x standard;
- an Ontario Hydro commitment to reduce NO_x emissions by 40 per cent of 1985 base levels by year 2000;
- Countdown Acid Rain Program which indirectly limits the emissions of NO_x from Ontario Hydro fossil fuelled stations;
- A Voluntary Vehicle Inspection and Maintenance Program;
- Scientific studies to help formulate control strategies for the NO_x/VOC Management Plan.

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APPENDIX A - MONITORING NETWORK OPERATIONS

1.0 Network Description

In 1971, the provincial monitoring network consisted of 254 instruments: 166 continuous analyzers at 76 monitoring sites and 88 sites with Hi-vol samplers. By 1980, the provincial network had reached its maximum size at 450 instruments of which 268 were continuous analyzers at 106 sites and 182 Hi-vol monitors. Since 1980, the total number of instruments operating across Ontario has decreased by about 28 per cent. In 1994, the network consisted of 323 instruments: 229 continuous monitors distributed at 85 sites to monitor up to nine different gaseous contaminants, and Hi-vol samplers at 94 sites. Figure A-1 shows the distribution of the number of instruments operating in Ontario since 1971.

The Ministry of Environment and Energy is divided into six Regions. Each Region has an Atmospheric and Terrestrial Unit which is responsible for the day-to-day operation and maintenance of the air monitoring analyzers. Through a computer telephone link, the technicians remotely check the automatic "zero" and "span" values each day to determine the stability of the instruments. The span gases used for these daily checks are assigned concentration values by the Instrumentation and Quality Assurance Unit of the Environmental Monitoring and Reporting Branch.

Regional technicians perform regular inspections and maintenance on the monitoring equipment and stations. If an instrument undergoes major servicing, the Instrumentation and Quality Assurance Unit may be requested to perform a calibration to confirm proper operation of the analyzer.

Portable calibration equipment is used by regional staff in evaluating instrument performances. This equipment is calibrated by the Instrumentation and Quality Assurance Unit a minimum of twice per year.

1.1 Quality Assurance and Quality Control

The Environmental Monitoring and Reporting Branch maintains a laboratory with gas reference standards that adhere to those of the U.S. National Institute of Standards and Technology (NIST) as well as to the Pollution Measurement Division of Environment Canada. Performance audits are conducted on the SO_2, NO/NO_2, O_3 and TRS (as H_2S) monitors three times per year and on CO and hydrocarbon (as methane) monitors once per year. Deviation of less than or equal to ± 10 per cent from the audit standard is the principal criterion for performance acceptability.

The ambient air quality monitoring network is subjected to continuous maintenance and quality control programs.

The real-time continuous and particulate air quality data are constantly reviewed, assessed and validated by Regional staff and staff of the Environmental Monitoring and Reporting Branch. Remedial actions are taken immediately to rectify any problems that may affect the validity of the data.

In 1994, the provincial continuous air monitoring instruments were subjected to 757 performance audits. Six per cent of the audits were found to be within the acceptable performance criterion of less than or equal to ± 10 per cent. For the remaining 14.4 per cent which fell outside the 10 per cent range, station log records and backup charts were consulted to correct data. As a result, the MOEE monitoring network for 1994 had 94.1 per cent valid data.

1.2 Data Base

The ambient air quality data used in this report are stored in MOEE's Air Quality Information System (AQUIS). Approximately 4 million air pollution measurements are added to AQUIS on an annual basis with the vast majority representing the more heavily populated urban areas within Ontario.

A statistical test, the pattern test, is used as a data screening procedure to identify data anomalies. The pattern test checks for unusual pollutant behaviour. A set of limits for each pollutant has been defined from historical data. Values that are outside these limits are flagged for further investigation.

The AQUIS data are divided into three major groupings: continuous (1-hour) measurements, daily (24-hour) measurements, and monthly (30-day) measurements.

The hourly data are obtained from ambient air monitoring instruments that operate continuously, producing a measurement every hour for a possible total of 8760 hourly measurements in a year. A valid annual mean requires at least 5840 hourly readings or 67 per cent valid data.

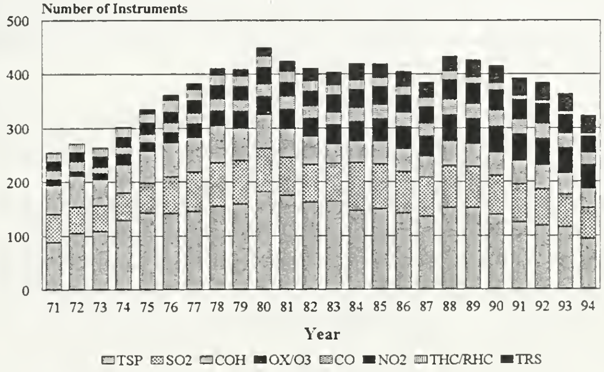
The daily measurements are obtained from instruments that provide one measurement from a 24-hour sampling period and are typically operated on 1,3 or 6 day cycles. Such instruments are used to measure total suspended particulates, inhalable particulate, lead, various trace metals, sulphate and nitrate. For daily data, a valid annual mean requires at least two thirds of the total number of possible samples, i.e., a station operating on a 6-day sampling schedule would require at least 40 out of a possible 61 samples.

The monthly data are collected over a 30-day period producing 12 monthly measurements per year. A valid annual mean requires at least seven out of a possible 12 values.

In order for a monitoring site to have been included in the 10-year trend analysis, the site had to have a valid annual mean for at least 8 out of the 10 years 1985-1994, and to be included in the "long term" trend analysis the site had to have a valid mean for at least 18 out of the 24-years, 1971-1994.

FIGURE A1

Ontario Ambient Air Quality Monitoring Program from 1971 to 1994



Note Does not include meteorological sensors and toxic organic chemical monitors

APPENDIX B - GLOSSARY AND ABBREVIATIONS

Acidic Deposition	-	Refers to deposition of a variety of acidic pollutants (acids or acid-forming substances such as SO_3 and NO_3) on biota or land or in waters of the earth's surface.
Air Quality Index	-	A real-time information system that provides the public with an indication of air quality in major cities across Ontario.
Air Pollution Index	-	The basis of an alert and control system to warn of deteriorating air quality. It is derived from 24-hour running averages of SO_2 and SP.
Ambient Air	-	The portion of the atmosphere, external to buildings, to which the general public has access; open air.
Anthropogenic	-	Referring to environmental alterations resulting from the presence or activities of humans.
"Approvals Screening Levels"	-	A means of protecting the environment and its inhabitants when standards are currently not available. The primary use of "Approvals Screening Levels" is for judging the acceptability of model predicted ground level concentrations associated with Certificate-of-Approvals applications.
Background Radiation	-	The radiation in humans' natural environment, including cosmic rays and radiation from the naturally radioactive elements. Also known as natural radiation.
Bioaccumulation	-	The process by which contaminants in the environment accumulate in living organisms, either directly through the consumption of a food source, or indirectly through the environment.
Carcinogenic	-	An agent that incites development of carcinoma or any other sort of malignancy.
Chlorofluorocarbon	-	A family of inert, non-toxic and easily liquified chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants. Since CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere where their chlorine compounds destroy ozone.

Coefficient of Haze - The coefficient of haze measurement yields an estimate of the amount of fine suspended particulate matter by measuring the amount of light transmission.

"Continuous" pollutant - A contaminant for which a continuous record exists; effectively, pollutants which have hourly data (maximum 8760 values per year).

Correlation coefficient - A measure of the strength of the relationship between two variables.

Criterion - A desirable maximum ambient air concentration or level (based on potential effects).

"Daily" pollutant - A contaminant for which there exists only a 24-hour or daily value (maximum 365 values per year).

Detection limit - The minimum concentration of a compound contaminant that can be determined by a specified analytical method.

Fossil Fuels - Pertains to natural gas, petroleum, coal and any form of solid, liquid or gaseous fuel derived from such materials for the purpose of creating heat.

Gas Chromatography - A separation technique involving passage of a gaseous moving phase through a column containing a fixed absorbent phase; it is used principally as a quantitative analytical technique for volatile compounds.

Geometric mean - A statistic of a data set calculated by taking the nth root of the product of all(n) values in a data set. Provides a better indication than arithmetic mean of the central tendency for a small data set with extreme values.

Global Warming - A long-term rise in the average temperature of the earth. This is principally due to a magnification in the greenhouse effect.

Great Lakes Basin - The area drained by Lakes Superior, Michigan, Huron, Erie and Ontario, including all streams, rivers and other bodies of water.

Greenhouse Effect - The heating effect of the atmosphere upon the earth. Light waves from the sun pass through the air and are absorbed by the earth. The earth then radiates this energy as heat waves that are absorbed by the air, specifically carbon dioxide. The air behaves like a glass in a greenhouse, allowing the passage of light but

		not of heat.
Greenhouse Gases	-	A collective term for carbon dioxide, carbon monoxide, chlorofluorocarbons, ground-level ozone, methane, nitrogen oxides and volatile organic compounds.
Ground-level Ozone	-	A colourless gas formed from chemical reactions between nitrogen oxide and hydrocarbons in the presence of sunlight.
Halons	-	Hydrocarbons (usually methane or ethane) in which the atoms of hydrogen have been replaced by atoms of halogens such as fluorine, chlorine or bromine.
Herbicide	-	A chemical pesticide designed to destroy or control plants, weeds and grasses.
Inhalable Particulate	-	An appreciative amount, up to 60 per cent, of the total suspended particulate matter. It is comprised of both primary (diameter 2.6 to 10.0 microns) and fine (diameter ≤ 2.5 microns) particles. Also referred to as PM_{10}.
Isomer	-	One of two or more chemical substances having the same elementary percentage composition and molecular weight but differing in structure and therefore in properties; an example of an isomer differing in structure is the compounds *n*-butane ($CH_3(CH_2)_2CH_3$) and isobutane ($CH_3CH(CH_3)_2$).
Landfill	-	A disposal facility or part of a facility where regulated waste is placed in or on the land. Also known as waste disposal site.
Mesoclimate	-	The climate of small areas of the earth's surface which may not be representative of the general climate of the district.
Microclimate	-	The climatic condition of a small area resulting from the modification of the general climatic conditions.
Microenvironment	-	The specific environmental factors in a *microhabitat*.
Microhabitat	-	A small, specialized and effectively isolated location.
"Monthly" pollutant	-	A contaminant for which there exists only a monthly (30-day) value (maximum 12 values per year).

Mutagen	An agent that raises the frequency of mutations above the spontaneous rate.
Ozone "episode day"	A day on which widespread (hundreds of kilometres) elevated ozone levels (greater than 80 ppb maximum hourly concentration) occur simultaneously.
Particulate Matter	Refers to any airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 100 micrometres.
Percentile value	The percentage of the data set that lies below the stated value. For example, if the 70 percentile value is 0.10 ppm, then 70 per cent of the data are equal to or below 0.10 ppm.
Pesticide	Any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any plant pest.
pH	A numerical expression of the concentration of hydrogen ions in solution ($0<\text{pH}<7$ is acidic, $\text{pH}=7$ is neutral and $7<\text{pH}<14$ is alkaline).
Photochemical Oxidant	Any of the chemicals which enter into oxidation reactions in the presence of light or other radiant energy.
Photochemical Reaction	A chemical reaction influenced or initiated by light, particularly *ultraviolet* light.
Photochemical Smog	See *smog*.
Precipitation	Pertains to rainfall and snowfall.
Primary pollutant	A contaminant which is directly emitted to the atmosphere.
Radioactivity	A particular type of radiation emitted by a radioactive substance such as alpha radiation.
Radionuclide	A nuclide that exhibits *radioactivity*.
Secondary pollutant	A contaminant which is formed from other pollutants present in the atmosphere.
Smog	Literally a contraction of "smoke" and "fog"; the colloquial term used for photochemical fog, which includes ozone and other contaminants; it tends to provide a brownish haze to the atmosphere.
Stratosphere	That portion of the atmosphere located 10 to 40 kilometres above the earth's surface.

Stratospheric Ozone - Ozone that is formed in the stratosphere from the conversion of oxygen molecules by solar radiation. Ozone absorbs much ultraviolet radiation and prevents it from reaching the Earth.

Suspended Particles - A relative measure of suspended particulate matter of size most likely to reach the lungs (diameter less than 5-10 microns). It is determined by the amount of light transmission due to the trapping of particles on a filter medium and is expressed as coefficient of haze (COH).

Taxonomic - A hierarchical system of classification of organisms which best reflects the totality of similarities and differences.

Threshold Limit Value - Refers to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.

Total Suspended Particulate - A generic term for airborne particles including smoke, fume, dust, fly ash and pollen. Size range is approximately 0.1 to 100 microns in diameter.

Toxic Deposition - The absorption or adsorption of a toxic pollutant at ground, vegetative or surface levels.

"Toxic" pollutant - Substance that can cause cancer, genetic mutations, organ damage, changes to the nervous system, or even physiological harm as a result of prolonged exposure, even to relatively small amounts.

Toxicity Equivalent - Toxicity equivalent of chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans is calculated as follows: International toxicity equivalency factors (I-TEFs) are applied to 17 dioxin and furan isomers of concern to convert them into 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) toxicity equivalents. The conversion involves multiplying the concentration of the isomer by the appropriate I-TEF to yield the TEQ for this isomer. Summing the individual TEQ values for each of the isomers of concern provides the total toxicity equivalent level for the sample mixture. A table listing the 17 isomers of concern and their I-TEFs can be found in the MOEE publication titled: Environment Information - Dioxin & Furans; PIBS 681b, revised 08/91.

Troposphere - The layer of atmospheric air extending 10 kilometres upwards from the earth's surface.

Watershed - The area drained by a river or lake system. Otherwise known as a drainage area, drainage basin or catchment area.

Wet Deposition - A process of precipitation whereby acidic chemicals, including dilute sulphuric and nitric acids and sulphates, are deposited in the form of rain, snow, fog, etc. See also *acidic deposition*.

ABBREVIATIONS

AAQC	Ambient Air Quality Criterion
ABS	Acrylonitrile-Butadiene-Styrene
API	Air Pollution Index
AQI	Air Quality Index
AQUIS	Air Quality Information System
ASLs	Approvals Screening Levels
B[a]P	Benzo [a] Pyrene
CEPA	Canadian Environmental Protection Act
CFC	Chlorofluorocarbons
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COH	Coefficient of Haze reported as SP
DU	Dobson Unit; 100 DU equal an imaginary layer of pure ozone gas 1 mm thick at standard sea level temperature and pressure
EC	Environment Canada
ELEV	Elevation of sampling inlet (metres above ground)
EMRB	Environmental Monitoring and Reporting Branch
EST	Eastern Standard Time
GC	Gas Chromatography
GC-FID	Gas Chromatography Flame Ionisation Detector
GC-MSD	Gas Chromatography Mass Selective Detector
GEMS	Global Environment Monitoring System
HCFCs	Hydrochlorofluorocarbons
H_2S	Hydrogen Sulphide
INS	Insufficient data to calculate statistic
ICRP	International Commission on Radiation Protection
IJC	International Joint Commission
IP	Inhalable Particulates
KHC	Known Human Carcinogen
LAT	Latitude
LIMA	Lambton Industry Meteorological Alert
LONG	Longitude
MOE	Ontario Ministry of the Environment
MOEE	Ontario Ministry of Environment and Energy
NAAQC	National Ambient Air Quality Criterion
NAAQS	National Ambient Air Quality Standard
NAPCC	National Action Program on Climate Change
NIST	National Institute of Standards and Technology
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_X	Nitrous Oxides
O_3	Ozone
ODS	Ozone Depleting Substances

OEIS - Ontario Emission Inventory System
PAH - Polycyclic Aromatic Hydrocarbon
Pb - Lead
PCDD - Polychlorinated Dibenzo Dioxins
PCDF - Polychlorinated Dibenzo Furans
PIFs - Potentially Injurious Fumigations
$PM_{2.5}$ - Particulate Matter less than 2.5 micrometers
PM_{10} - Particulate Matter less than 10 micrometers
PUF - Polyurethane Foam
PVC - Polyvinylchloride
RHCs - Reactive Hydrocarbons
SHC - Suspected Human Carcinogen
SO_2 - Sulphur Dioxide
SO_x - Sulphur Oxides
SP - Suspended Particles
SVOCs - Semi-volatile Organic Compounds
TEQ - Toxicity Equivalent
THCs - Total Hydrocarbons
TLV - Threshold Limit Value
TRS - Total Reduced Sulphur
TSP - Total Suspended Particulates
UNEP - United Nations Environmental Programme
USEPA - United States Environmental Protection Agency
UV - Ultraviolet Radiation
VOCs - Volatile Organic Compounds
WHO - World Health Organization
XAD-2 - Polymeric Resin

$g/m^2/30$ days - grams (of contaminant) per square metre per 30-day period
kg - kilogram
kPa - kiloPascal
kt - kilotonne
mm - millimetre
mSv - millisieverts
$\mu g/m^3$ - micrograms (of contaminant) per cubic metre (of air)
$\mu g/100\ cm^2$/month - micrograms (of contaminant) per 100 square centimetres per month
pg/m^3 - picograms, i.e. a millionth of a microgram (of contaminant) per cubic metre (of air)
ppb - parts (of contaminant) per billion (parts of air)
ppm - parts (of contaminant) per million (parts of air)
pphm - parts (of contaminant) per hundred million (parts of air)
rem - unit of effective absorbed dose of ionizing radiation in human tissue - 'roentgen equivalent man'

APPENDIX C - NETWORK DESCRIPTIVE TABLES AND SUMMARY STATISTICS

In previous air quality reports the annual statistics appeared in a separate volume however, for this years publication it was decided to include the annual statistics in an appendix as part of the comprehensive report. For each pollutant, tables provide the station location as well as a listing of the summary statistics including, means, maxima, percentile values and the number of exceedances of the Ontario criteria.

The entire continuous (hourly) network is summarized in Table C-1. The table gives station name, numerical identifier, and pollutants measured. The numerical identifier is the station (ID) number, the first digit of which identifies the geographic region in which the station is located.

The Ministry of the Environment and Energy has divided the province into 7 regions. Region 1 (Southwest) with headquarters in London; Region 2 (West Central) with headquarters in Hamilton; Region 3 and 4 (Central) with headquarters in Toronto; Region 5 (Southeast) with headquarters in Kingston; Region 6 (Northwest) with headquarters in Thunder Bay and finally Region 7 (Northeast) with headquarters in Sudbury. The column headings for pollutants are as follows:

SO_2	(sulphur dioxide)
SP	(suspended particles)
CO	(carbon monoxide)
O_3	(ozone)
NO_2	(nitrogen dioxide)
NO	(nitric oxide)
NO_x	(oxides of nitrogen)
THC	(total hydrocarbon compounds)
TRS	(total reduced sulphur compounds)
API	(air pollution index)
AQI	(air quality index)

The particulate (daily) network is summarized in Table C-2 The table gives station name, numerical identifier, and pollutants measured. Numerals indicate the monitoring cycle frequency in days. Some additional codes are defined in the key at the top of the table. The column headings for pollutants are as follows:

TSP	(total suspended particulate)
Cd	(cadmium in TSP)
Cr	(chromium in TSP)
Fe	(iron in TSP)
Mn	(manganese in TSP)
Ni	(nickel in TSP)
Pb	(lead in TSP)
V	(vanadium in TSP)
NO_3^-	(nitrate in TSP)
SO_4^{2-}	(sulphate in TSP)

The particulate (monthly) network is summarized in Table C-3. This table gives the location of the monitoring site and the parameters measured at each site.

The inhalable particulate (PM-10) network is summarized in Table C-4. This table gives the station location, parameters measured and frequency of sampling.

The meteorological network is summarized in Table C-5. This table gives station name, numerical identifier, meteorological parameters measured and the height of the measurements.

The 1994 statistical data for the various pollutants are provided in Tables C-6 through C-16. Due to serious and prolonged failure of analytical equipment no metal results were available for 1994, at the time of printing this appendix.

Stations used in the trends of gases and particulates are listed in Tables C-01and C-02.

Table C-01

STATIONS USED IN TRENDS OF GASES (1985-1994)

City	Station(Period)
Burlington	44008 (1985 - 1994)
Cornwall	56051 (1985 - 1994)
Etobicoke	35003 (1985 - 1994)
Fort Frances	62030 (1985 - 1994)
Hamilton	29025 (1985 - 1986);29000 (1987-1994)
Huron Park	10001 (1985 - 1990);15020 (1991-1994)
Kitchener	26029 (1985 - 1990);26060 (1991-1994)
London	15001 (1985 - 1994)
Long Point	22901 (1985 - 1994)
Mandaumin	14118 (1985 - 1994)
Merlin	13021 (1985 - 1994)
Mississauga	46110 (1985 - 1994)
Niagara Falls	27056 (1985 - 1994)
North Bay	75010 (1985 - 1994)
Oakville	44015 (1985 - 1994)
Oshawa	45025 (1985 - 1994)
Ottawa	51001 (1985 - 1994)
Peterborough	59006 (1985 - 1994)
Sarnia	14064 (1985 - 1994)
Scarborough	33003 (1985 - 1994)
Simcoe	22071 (1985 - 1994)
St Catharines	27037 (1985 - 1986);27067 (1987-1994)
Stouffville	48002 (1985 - 1994)
Sudbury	77016 (1985 - 1987);77203 (1988-1994)
Thunder Bay	63040 (1985 - 1986);63200 (1987-1994)
Tiverton	18007 (1985 - 1994)
Toronto	31104 (1985 - 1990);31103 (1991-1994)
Windsor	12008 (1985 - 1994)

Table C-02

STATIONS USED IN TRENDS OF PARTICULATES (1985-1994)

City	Station (Period)
Burlington	44008 (1985 - 1994)
Courtright	14016 (1985 - 1994)
Etobicoke	35003 (1985 - 1994)
Espanola	77029 (1985 - 1994)
Fort Frances	62032 (1985 - 1994)
Hamilton	29025 (1985 - 1994)
Jarvis	22092 (1985 - 1994)
Kitchener	26029 (1985 - 1990);26060 (1991-1994)
London	15001 (1985 - 1994)
Mississauga	46110 (1985 - 1994)
Oakville	44015 (1985 - 1994)
Port Colborne	27047 (1985 - 1994)
S.S. Marie	71049 (1985 - 1994)
Sarnia	14064 (1985 - 1994)
Scarborough	33003 (1985 - 1994)
St Catharines	27008 (1985 - 1994)
St Thomas	15006 (1985 - 1994)
Sudbury	77026 (1985 - 1994)
Thunder Bay	63005 (1985 - 1994)
Toronto	31104 (1985 - 1990);31103 (1991-1994)
Welland	27045 (1985 - 1994)
Windsor	12008 (1985 - 1994)

TABLE C-1

ONTARIO AIR MONITORING NETWORK FOR 1994, HOURLY DATA

T = TELEMETRY L = DATA LOGGER YR = YEAR STATION BEGAN
TYPE = A:AMBIENT SURVEY; I:SOURCE SPECIFIC SURVEY; LAT = LATITUDE(DEGREES:MINUTES)
ID = STATION IDENTIFICATION NUMBER
LONG = LONGITUDE(DEGREES:MINUTES)
ELEV = AIR INTAKE HEIGHT ABOVE GROUND (M)

CITY	STATION NAME	ID	TYPE	YR	LAT	LONG	ELEV (M)	S02	COH	CO	O3	NO2	NO	NOx	THC	TRS	API	AQI
WINDSOR	WRIGHT/WATER ST	12007	I	84	42:17	83.06	4	T								T		
WINDSOR	467 UNIVERSITY AV W	12008	A	69	42:19	83.03	8	T	T	T	T	T	T	T			T	T
WINDSOR	COLLEGE/SOUTH ST	12016	A	75	42.18	83.04	4	T	T		T					T	T	T
MERLIN	MOE WATER PUMP STN, MIDDLE RD	13021	A	77	42:15	82:13	4				T							
COURTRIGHT	HWY40 (OPP LAMBTON GS)	14016	A	69	42.48	82.29	4	T										
SARNIA	CENTENNIAL PK,FRONT ST/CN TRACKS	14064	A	76	42.59	82:24	3	T	T	T	T	T	T	T		T	T	T
MANDAUMIN	CONCESSION RD 26	14118	A	77	42:56	82:14	4				T							
LONDON	WRN FAIR GROUNDS, KING/RECTORY	15001	A	70	42:59	81:13	4	T	T	T	T	T	T	T			T	T
LONGWOODS	LONGWOODS CONSERVATION AUTH	15009	A	83	42.53	81.29	4				T							
PARKHILL	PUC BUILDING	15013	A	83	43:10	81:41	5				T	T	T	T				
LONDON	951 COMMISSIONERS RD E	15015	I	86	42:58	81:13	4	L										
LONDON	801 COMMISSIONERS RD E	15016	I	86	42.57	81:13	4	L										
LONDON	8 MOUNTSFIELD DR	15017	I	86	42:58	81:15	4	L										
GRAND BEND	POINT BLAKE (CONSERVATION AREA)	15020	A	91	43:20	81:44	4				T							
TIVERTON	CONCESSION RD 2 LOT A	18007	A	79	44:18	81:35	4	T			T					T		
SIMCOE	EXPERIMENTAL FARM	22071	A	75	42.51	80.16	4	T			T	T	T	T				
NANTICOKE	CHEAPSIDE RD(3 KM S OF HWY 3)	22086	I	77	42.52	80.00	5	T				T	T	T				
TOWNSEND	TOWNLINE RD/CON 13	22094	I	86	42.54	80.09	4	T										
LONG POINT	PROVINCIAL PARK	22901	A	79	42.35	80.23	4	T			T	T	T	T				
NANTICOKE	WALPOLE S PS, SANDUSK RD	22904	I	79	42.50	80.02	4									T		
NANTICOKE	RAINHAM RD (NEAR STELCO GATE)	22907	I	84	42.49	80.05	4	T	T							T		
KITCHENER	WEST AVE/HOMEWOOD	26060	A	90	43:26	80.30	5	T	T	T	T	T	T	T			T	T
ELMIRA	ELMIRA	26069	I	93	43.35	80.30	5	T	T			T	T	T		T		
NIAGARA FALLS	STP GROUNDS, STANLEY AV	27055	I	83	43.08	79.05	4									T		
CHIPPAWA	HOLY T CHURCH, NORTON/PORTAGE	27051	I	79	43.04	79.04	16									T		
ST CATHERINES	ARGYLE CRESCENT	27067	A	87	43.10	79.14	4	T	T	T	T	T	T	T			T	T
NIAGARA FALLS	STANLEY/HWY 405	27072	A	93	43.06	79.05	5	T	T		T						T	T
CHIPPAWA	CHIPPAWA/REILLY	27077	I	79	43.04	79.04	6									T		
GUELPH	EXHIBITION ST/CLARK ST	28028	A	86	43:33	80.16	4				T							
HAMILTON	ELGIN/KELLY	29000	A	87	43.15	79.52	4	T	T	T	T	T	T	T	T	T	T	T
HAMILTON	HUGHSON/HUNTER	29001	A	61	43.15	79.52	9		T									
HAMILTON	BARTON/SANFORD	29025	I	69	43:16	79.51	4	T	T							T		
HAMILTON	467 BEACH BLVD	29102	I	84	43.17	79.47	4	T	T			T	T	T		T		
HAMILTON	NASH RD/KENTLEY DR	29105	A	85	43.14	79.46	4	T	T		T					T	T	T
HAMILTON	VICKERS RD/EAST 8TH ST.	29114	A	85	43.14	79.52	3	T	T		T	T	T	T		T	T	T
HAMILTON	MAIN ST/W HWY 403	29118	A	85	43:15	79.54	3	T	T	T	T	T	T	T		T	T	T
HAMILTON	PIER 25/BEACH STRIP	29547	I	92	43.27	79.78	4									T		
HAMILTON	VANSITMART AVE.	29561	I	94	43.56	78:18	4	T	T							T		
TORONTO	MISSION, 381 YONGE ST.	31049	A	72	43.40	79.23	4		T	T		T	T	T				
TORONTO	BAY/GROSVENOR ST.	31103	A	90	43.39	79.23	3	T	T	T	T	T	T	T	T		T	T
TORONTO	PERTH/RUSKIN(JUNCTION TRIANGLE)	31120	A	81	43.40	79.27	9	T	T	T	T	T	T	T	T		T	T
SCARBORO	LAWRENCE/KENNEDY	33003	A	70	43.45	79.16	4	T	T	T	T	T	T	T			T	T
NORTH YORK	HENDON AVE (YONGE ST/FINCH AVE)	34020	A	88	43:47	79.25	5	T	T	T	T	T	T	T			T	T
ETOBICOKE	ELMCREST RD (CENTENNIAL PK)	35003	A	69	43.39	79.35	5	T	T	T	T	T	T	T			T	T
ETOBICOKE	EVANS/ARNOLD AV	35033	A	67	43.37	79:31	5	T	T	T	T	T	T	T	T		T	T
YORK	CLEARVIEW HEIGHTS	36030	A	88	43:42	79.29	5	T	T	T	T	T	T	T			T	T
BURLINGTON	HWY2/NORTH SHORE BLVD E.	44008	A	79	43:19	79.48	5	T	T	T	T	T	T	T			T	T
OAKVILLE	BRONTE RD/WOBURN CRES	44015	A	80	43.24	79.44	5	T	T	T	T	T	T	T	T	T	T	T
OSHAWA	PS, RITSON RD/OLIVE AV	45025	A	79	43.53	78.51	5	T	T	T	T	T	T	T			T	T
MISSISSAUGA	QUEENSWAY W/HURONTARIO ST	46110	A	77	43:34	79.37	5	T	T	T	T	T	T	T			T	T
MISSISSAUGA	MEADOW PK, APPLE LANE C C	46117	I	87	43:31	79.36	5	T							T	T		
ALLISTON	509 VICTORIA ST E	47035	A	81	44.09	79.51	4				T							
STOUFFVILLE	HWY47/E OF HWY48	48002	A	74	43:58	79.16	5	T			T	T	T	T				
DORSET	HWY 117/PAINT LAKE ROAD	49010	A	81	45:13	78.56	3	L			L	L	L	L				
OTTAWA	MCD GDS, RIDEAU/WURTENBURG ST	51001	A	71	45:26	75.41	4	T	T	T	T	T	T	T			T	T

TABLE C-1

ONTARIO AIR MONITORING NETWORK FOR 1994, HOURLY DATA

T = TELEMETRY L = DATA LOGGER YR = YEAR STATION BEGAN
TYPE = A:AMBIENT SURVEY; I:SOURCE SPECIFIC SURVEY; LAT = LATITUDE(DEGREES:MINUTES)
ID = STATION IDENTIFICATION NUMBER
LONG = LONGITUDE(DEGREES:MINUTES)
ELEV = AIR INTAKE HEIGHT ABOVE GROUND (M)

CITY	STATION NAME	ID	TYPE	YR	LAT	LONG	ELEV (M)	S02	COH	CO	O3	NO2	NO	NOx	THC	TRS	API	AQI
KINGSTON	DALTON STREET	52020	A	88	44.14	76.31	5		T		T							T
CORNWALL	MEMORIAL PK, BEDFORD/THIRD STS.	56051	A	70	45.01	74.44	4	T	T	T	T	T	T	T		T	T	T
CORNWALL	SCHOOL, 435 SECOND ST W	56068	I	75	45.01	74.44	6									T		
PETERBOROUGH	MOEE LANSDOWNE ST.	59006	A	76	44.16	78.21	7				T							
DRYDEN	35 VAN HORNE AV.	61027	I	84	49.47	92.50	15									T		
FORT FRANCES	PORTAGE/CHURCH ST.	62030	I	76	48.37	93.24	4		T		T					T		T
FORT FRANCES	CEMETERY,COLONIZATION RD W	62032	I	76	48.37	93.25	5									T		
FORT FRANCES	EIGHTH ST/CORNWALL AVE.	62047	I	90	48.37	93.24	4									T		
FORT FRANCES	LA VERENDRYE HOSPITAL	62051	I	90	48.36	93.23	3									T		
ELY MINNESOTA	FERNBERG RD. ELY MINNESOTA	62068	A	91	47.57	91.30	5				T							
MARATHON	WATER TOWER	63033	I	91	48.43	86.23	4									T		
THUNDER BAY	CAN-CAR, MONTREAL ST	63046	I	76	48.21	89.18	3		T	T						T		
RED ROCK	RECREATION CENTRE	63084	I	81	48.57	88.15	7									T		
TERRACE BAY	ST MARTIN SCHOOL	63090	I	81	48.47	87.06	8									T		
TERRACE BAY	TERRACE HEIGHTS DRIVE	63092	I	94	48.47	87.05	5									T		
TERRACE BAY	MILL RD/SOUTH CAMP RD.	63093	I	89	48.47	87.05	4									T		
CLOUD RIVER	CLOUD RIVER	63120	A	92	48.09	89.27	4				T							
THUNDER BAY	MTC 615 JAMES ST S	63200	A	86	48.23	89.17	3	T	T	T	T	T	T	T		T	T	T
SAULT STE MARIE	WM MERRIFIELD SCHOOL	71068	A	87	46.32	84.21	3	T	T		T	T	T	T		T	T	T
WAWA	HWY 17 WEST (KOA CAMPGROUND)	71077	I	94	47.59	84.56	5	T										
SMOOTH ROCK FALLS	ROSS ROAD	72084	I	86	49.17	81.37	4									T		
NORTH BAY	OPP STATION	75010	A	79	46.19	79.27	4		T		T							T
SUDBURY	SKEAD	77012	I	52	46.39	80.46	4	T										
SUDBURY	HANMER	77013	I	73	46.39	80.57	5	T										
SUDBURY	WATER TANK ASH ST.	77016	I	69	46.30	81.00	3	T										
CONISTON	GOVERNMENT ROAD/EDWARD ST.	77028	I	74	46.29	80.51	4	T										
GARSON	FALCONBRIDGE ROAD	77065	I	76	46.34	80.51	4	T										
NEW SUDBURY	SPARKS STREET	77075	I	76	46.31	80.57	4	T										
SUDBURY	LONG LAKE ROAD (VILLA LOYOLA)	77096	I	80	46.24	81.01	4	T										
SUDBURY	MIKKOLA (J. HAMILTON SCHOOL)	77201	I	82	46.25	81.07	4	T										
SUDBURY	SCIENCE NORTH	77203	A	84	46.28	80.59	15	T	T	T	T	T	T	T		T	T	T
RAYSIDE	ST LAURENT/REGIONAL RD	77206	I	85	46.36	81.06	4	T										
COPPER CLIFF	MARKET STREET	77218	I	87	46.28	81.04	4	T										
SUDBURY	1412 STEPHEN STREET	77225	I	90	46.28	81:00	4	T										
SUDBURY	DOZZI PARK	77228	I	93	46.28	81.02	4	T										
TOTALS:								58	38	24	45	33	33	33	5	37	27	30

LEGEND:

SO2 - Sulphur Dioxide
COH - Coefficient of Haze
CO - Carbon Monoxide
O3 - Ozone
NO2 - Nitrogen Dioxide
NO - Nitric Oxide
NOX - Oxides of Nitrogen

THC - Total Hydrocarbon
TRS - Total Reduced Sulphur
API - Air Pollution Index
AQI - Air Quality Index

TABLE C-2

ONTARIO AIR MONITORING NETWORK FOR 1994, DAILY DATA

SINGLE DIGITS = CYCLE DURATION IN DAYS
TYP = A:AMBIENT SURVEY; I:SOURCE SPECIFIC SURVEY
ELEV = AIR INTAKE HEIGHT ABOVE GROUND (METRES)
ID = STATION IDENTIFICATION NUMBER
LAT = LATITUDE(DEGREES:MINUTES)
LONG = LONGITUDE(DEGREES:MINUTES)

CITY	STATION NAME	ID	TYPE	YR	LAT	LONG	ELEV (M)	TSP	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	NO3	SO4	Cl	Sb	C	RAD
ST. MARYS	309 THOMAS ST	11001	I	79	43:15	81:09	3	6														
WINDSOR	7730 RIVERSIDE DR E	12005	A	78	42:20	82:57	7	6	6	6	6	6	6	6	6	6						
LA SALLE	BEACH LANE/HWY 18	12006	A	83	42:14	83:06	4	6														
WINDSOR	WRIGHT/WATER ST	12007	I	84	42:17	83:06	4	6	6	6	6	6	6	6	6	6	6	6	6			
WINDSOR	467 UNIVERSITY AV W	12008	A	70	42:19	83:03	8	6	6	6	6	6	6	6	6	6	6	6				6
WINDSOR	9725 RIVERSIDE DR E LITTLE RIVER	12009	A	71	42:20	82:56	2	6							6							
WINDSOR	DROUILLARD RD/RICHMOND ST	12011	I	88	42:19	83:00	5	6	6	6	6	6	6	6	6	6						
WINDSOR	FILTRAT PLT,3665 WYANDOTTE ST E	12013	I	71	42:19	83:00	6	6	6	6	6	6	6	6	6	6						
WINDSOR	SEWAGE STN, HWY 18/PROSPECT	12015	A	71	42:17	83:05	5	6	6	6	6	6	6	6	6	6	6	6	6			
WINDSOR	COLLEGE/SOUTH ST	12016	A	75	42:18	83:04	4	6	6	6	6	6	6	6	6	6	6	6	6			
WINDSOR	1802 GEORGE AV	12036	A	77	42:19	82:59	4	6														
WINDSOR	3225 CALIFORNIA ST	12037	A	77	42:16	83:02	4	6														
WINDSOR	2885 HOWARD AVE	12038	I	78	42:17	83:01	4	6	6	6	6	6	6	6	6	6	6	6	6			
WINDSOR	DORWIN PLAZA, DOUGALL AV	12047	A	85	42:17	83:02	2	6	6	6	6	6	6	6	6	6	6	6	6			
AMHERSTBURG	415 FRONT ST	12053	I	81	42:08	83:07	11	6											6			6
AMHERSTBURG	DUFF ST. (EAST END)	12055	I	91	42:07	83:06	1	6											6			6
WINDSOR	COLUMBUS CENTRE	12058	I	93	42:17	83:01	5	6	6	6	6	6	6	6	6	6	6	6	6			
SARNIA	GENERAL HOSPITAL, 220 HITTON ST	14001	A	62	42:58	82:24	22	6														
COURTRIGHT	HWY40 (OPP LAMBTON GS)	14016	A	69	42:48	82:29	4	6	6	6	6	6	6	6	6	6	6	6				6
CORUNNA	R R #1 (W OF HOUSE)	14030	I	78	42:53	82:17	1	6	6	6	6	6	6	6	6	6						
MOORETOWN	R R. #1 (W OF BARN)	14031	I	78	42:52	82:18	1	6	6	6	6	6	6	6	6	6						
CORUNNA	ST CLAIR BLVD/HWY 40	14059	A	76	42:53	82:27	4	6														
SARNIA	CENTENNIAL PK,FRONT ST/CN TRACKS	14064	A	76	42:59	82:24	3	6	6	6		6	6	6	6	6	6	6				
SARNIA	DAVID/FRONT ST	14151	A	79	42:59	82:24	4	6														
LONDON	WRN FAIR GROUNDS, KING/RECTORY	15001	A	70	42:59	81:13	4	6	6	6	6	6	6	6	6	6						6
ST THOMAS	EDGEWARE RD (NNW VARTA PLT)	15008	I	81	42:48	81:09	3	6	6	6	6	6	6	6	6	6						
LONGWOODS	CONSERVATION AUTHORITY	15009	A	83	42:53	81:29	2	6														
LONDON	POND MILLS RD/DEVERON CRES	15014	I	86	42:58	81:12	5	6	6	6	6	6	6	6	6	6	6	6		6	6	
LONDON	951 COMMISSIONERS RD E	15015	I	86	42:58	81:13	4	6	6	6	6	6	6	6	6	6	6	6		6	6	
LONDON	801 COMMISSIONERS RD E	15016	I	86	42:57	81:13	4	6	6	6	6	6	6	6	6	6	6	6		6	6	
LONDON	8 MOUNTSFIELD DR	15017	I	86	42:58	81:15	5	6	6	6	6	6	6	6	6	6	6	6		6	6	
BEACHVILLE	CYANAMIDE RD (GORDON PROP)	17014	I	74	43:04	80:51	2	6														
BEACHVILLE	26 VINE ST (MOE TRAILER)	17015	I	89	43:04	80:51	4	6														
INGERSOLL	HWY 2 RR 2 (J SPRIEL PROP)	17020	I	81	43:04	80:51	4	6														
EMBRO	OXFORD CTY RD 6 (HESSTON FARM)	17021	I	83	43:06	81:58	1	6														
TIVERTON	CONCESSION RD 2 LOT A	18007	I	80	44:18	81:32	2															1
TIVERTON	CONCESSION RD 4 LOT D	18008	I	80	44:18	81:32	2															1
TIVERTON	CONCESSION RD 6 LOT E	18009	I	80	44:19	81:32	2															1
TIVERTON	CONCESSION RD 8 LOT 6	18010	I	80	44:20	81:30	2															1
TIVERTON	CONCESSION RD 10 LOT F	18011	I	80	44:21	81:30	2															1

TABLE C-2

ONTARIO AIR MONITORING NETWORK FOR 1994, DAILY DATA

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LAT =LATITUDE(DEGREES:MINUTES)
ELEV = AIR INTAKE HEIGHT ABOVE GROUND (METRES)
LONG = LONGITUDE(DEGREES:MINUTES)

CITY	STATION NAME	ID	TYPE	YR	LAT	LONG	ELEV (M)	TSP	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	NO3	SO4	Cl	Sb	C	RAD
NANTICOKE	RAINHAM RD/SANDUSK RD	22092	I	85	42:49	80:02	4	6													6	
NANTICOKE	WALPOLE S PS, SANDUSK RD	22904	I	84	42:50	80:02	4	6									6	6				
NANTICOKE	RAINHAM RD (NEAR STELCO GATE)	22907	I	84	42:49	80:05	4	6	6	6	6	6	6	6	6	6					6	
NANTICOKE	NANTICOKE RD/WALPOLE CON 2	22961	I	79	42:49	80:04	3	6														
NANTICOKE	N 2 KM NANTICOKE GS	22964	I	84	42:50	80:05	4	6														
ST. CATHARINES	71 KING ST	27008	A	87	43:10	79:15	12	6	6	6	6	6	6	6	6	6	6	6				6
WELLAND	337 ALBERTA/DEVON ST	27045	I	78	42:58	79:15	1	6													6	
PORT COLBORNE	DAVIS/FRAZER	27047	I	79	42:53	79:15	3	6						6								
THOROLD	185 QUEEN ST S	27052	I	82	43:07	79:12	1	6	6	6	6	6	6	6	6	6						
NIAGARA FALLS	STP GROUNDS, STANLEY AV	27055	I	82	43:08	79:05	4	6														
NIAGARA FALLS	HWY 405/STANLEY AV	27072	A	93	43:06	79:05	5	6														
GUELPH	HANLON EXPWY/SPEED RIVER	28027	I	81	43:55	80:26	6	6														
HAMILTON	ELGIN/KELLY	29000	A	88	43:15	79:52	4	6														
HAMILTON	KENILWORTH	29009	A	69	43:15	79:49	6	6														
HAMILTON	BURLINGTON/LEEDS	29011	I	73	43:16	79:49	5	6	6	6	6	6	6	6	6	6	6	6			6	
HAMILTON	CHATHAM/FRID	29017	I	69	43:15	79:54	5	6														
HAMILTON	BARTON/WENTWORTH	29025	I	69	43:16	79:51	4	6	6	6	6	6	6	6	6	6	6	6			6	
HAMILTON	450 HUGHSON ST N	29067	A	73	43:16	79:52	5	6	6	6	6	6	6	6	6	6						
HAMILTON	405 CUMBERLAND AV	29087	A	79	43:15	79:50	4	6														
HAMILTON	BAY/MAIN ST	29098	A	83	43:15	79:53	23	6	6	6	6	6	6	6	6	6	6	6				
HAMILTON	467 BEACH BLVD	29102	I	85	43:17	79:47	4	6	6	6	6	6	6	6	6	6	6	6				
HAMILTON	NASH/KENTLY DR	29105	A	85	43:13	79:46	4	6														
GREENSVILLE	OFIELD RD/HWY 5	29111	I	86	43:18	79:59	1	6														
GREENSVILLE	HARVEST RD/WESITE	29112	I	87	43:17	79:59	1	6														
HAMILTON	GERTRUDE/DEPEW	29113	I	86	43:15	79:49	4	6														
HAMILTON	VICKERS RD/EAST 18TH ST	29114	A	85	43:14	79:52	3	6	6	6	6	6	6	6	6	6	6	6				
HAMILTON	MAIN ST/W HWY 403	29118	A	85	43:15	79:54	3	6														
HAMILTON	MORLEY ST/PARKDALE AV	29119	I	86	43:15	79:47	4	6														
HAMILTON	DUNDURN/YORK	29122	A	87	43:16	79:53	10	6														
HAMILTON	BUCHANAN PARK PS	29124	A	88	43:14	79:53	4	6														
HAMILTON	EWEN RD/WHITNEY AV	29130	A	87	43:15	79:56	1	6														
HAMILTON	ALBRIGHT RD/MT ALBION RD	29135	A	87	43:13	79:48	8	6														
HAMILTON	KEEFER COURT/MOEE LAB	29143	I	92	43:24	79:76	4	6														
TORONTO	BRUCE PS, 51 LARCHMOUNT AV	31045	I	86	43:40	79:20	6	1							1							
TORONTO	MOSLEY/LESLIE STS	31058	I	73	43:40	79:20	5	1	1	1	1	1	1	1	1	1						
TORONTO	A R.CLARKE CO. 633 EASTERN AVE.	31065	I	87	43:40	79:20	12	1							1							
TORONTO	WORKS DEPT, 138 HAMILTON AV	31082	I	74	43:40	79:21	5	1							1							
TORONTO	TECUMSETH/NIAGARA ST	31085	I	79	43:38	79:24	5	6							6							
TORONTO	BAY/GROSVENOR	31103	A	81	43:40	79:23	1	1	1	1	1	1	1	1	1	1	1	1				6
TORONTO	FORT YORK	31183	I	87	43:38	79:24	1	6							6							

TABLE C-2

ONTARIO AIR MONITORING NETWORK FOR 1994, DAILY DATA

SINGLE DIGITS = CYCLE DURATION IN DAYS TYP = A:AMBIENT SURVEY; I:SOURCE SPECIFIC SURVEY ELEV = AIR INTAKE HEIGHT ABOVE GROUND (METRES)
ID = STATION IDENTIFICATION NUMBER LAT =LATITUDE(DEGREES:MINUTES) LONG = LONGITUDE(DEGREES:MINUTES)

CITY	STATION NAME	ID	TYPE	YR	LAT	LONG	ELEV (M)	TSP	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	NO3	SO4	Cl	Sb	C	RAD
NORTH YORK	111 FENMAR DRIVE	34034	I	92	43:45	79:33	2	6	6	6	6	6	6	6	6	6					6	
BOMANVILLE	91 QUEEN ST. (GOODYEAR TIRE)	45100	I	94	43.54	78 41	2	6														
MISSISSAUGA	2365 DIXIE RD	46045	I	73	43:36	79:35	5	1							1							
MISSISSAUGA	2360 DIXIE RD	46046	I	73	43:36	79:35	12	1							1							
MISSISSAUGA	MEADOW PARK, APPLE LANE C C	46117	I	87	43:31	79:36	5	6	6	6	6	6	6	6	6	6						
DORSET	HWY117 PAINT LAKE ROAD	49011	A	87	45:13	78.56	1	6														
FORT FRANCES	CEMETERY,COLONIZATION RD W	62032	I	76	48.37	93:25	5	6														
FORT FRANCES	LEGION BLDG, 250 CHURCH ST	62035	I	74	48:36	93.23	9	6														
THUNDER BAY	CAN-CAR, MONTREAL ST	63046	I	78	48:21	89.18	3	6														
THUNDER BAY	MTC 615 JAMES ST S	63200	A	86	48.23	89:17	3	6							6		6	6				
SAULT STE MARIE	PUMPHOUSE, BONNEY ST	71042	I	75	46 31	84 23	2	1				1	1								6	
SAULT STE MARIE	LAND OFFICE, QUEEN ST	71049	A	75	46:31	84:20	6	6				6	6		6						6	
SAULT STE MARIE	WM MERRIFIELD SCHOOL	71068	A	87	46:32	84 21	3	3				3	3		3		3	3			3	
WAWA	165 GOVERNMENT ROAD	71074	A	93	48:00	84 79	2	3				3	3		3							
WAWA	3 MAPLE STREET/WAWA COLLEGE	71075	A	93	47.99	84:78	2	3				3	3		3							
HEARST	TREMBLAY ST (E OF QUIRION)	72083	I	90	49 41	83:38	2	6														
ENGLEHART	KAPKIGIWAN RD	72102	I	94	47:49	79.53	3	6														
ENGLEHART	KING ST.	72103	I	94	47.50	79.53	3	6														
ENGLEHART	HOSPITAL	72107	I	94	47.85	79.88	3	6														
NEW LISKEARD	10169 LAKESHORE RD	75046	I	91	46:34	79.41	2	3														
SUDBURY	19 LISGAR ST	77026	A	72	46:30	81:00	8	6			6	6		6	6		6	6				
ESPANOLA	POST OFFICE, SPRUCE/BARBER ST	77029	A	77	46:16	81:46	6	6														
COPPER CLIFF	PUMPHOUSE, NICKEL ST	77070	I	76	46:28	81:04	5	6			6	6		6								
TOTALS:								**98**	**32**	**32**	**34**	**39**	**37**	**34**	**45**	**32**	**26**	**26**	**8**	**4**	**12**	**12**

LEGEND:

TSP - Total Suspended Particulate	Fe - Iron	V - Vanadium	Sb - Antimony
Cd - Cadmium	Mn - Manganese	N03 - Nitrate	C - Carbon
Cr - Chromium	Ni - Nickel	SO4 - Sulphate	RAD - Radiation
Cu - Copper	Pb - Lead	Cl - Chlorine	

TABLE C-3

ONTARIO AIR MONITORING NETWORK FOR 1994, MONTHLY DATA

1 = LAB ANALYSIS DONE FOR GIVEN PARAMETER
YR = YEAR STATION BEGAN
ID = STATION IDENTIFICATION NUMBER
TYP = A:AMBIENT SURVEY; I:SOURCE SPECIFIC SURVEY
ELEV = AIR INTAKE HEIGHT ABOVE GROUND (METERS)
LAT = LATITUDE (DEGREES:MINUTES)
LONG = LONGITUDE (DEGREES:MINUTES)

CITY	STATION NAME	ID	ELEV (M)	TYPE	LAT	LONG	YR	TDF	Cd	Co	Cr	Cu	Fe	Mn	Na	Ni	Pb	V	Zn	NO3	SO4	FLR	OM	OTHERS
WINDSOR	WRIGHT/WATER ST.	12007	4	I	42:17	83 06	85															1		
WINDSOR	SEWAGE STN, HWY 18/PROSPECT	12015	5	I	42 17	83.05	71															1		
AMHERSTBURG	415 FRONT STREET	12053	11	I	42.08	83:07	81															1		
AMHERSTBURG	57 NORTH STREET	12074	5	I	42.06	83.06	71															1		
AMHERSTBURG	459 TEXAS ROAD	12087	4	I	42:07	83 05	75															1		
AMHERSTBURG	326 TEXAS ROAD	12088	4	I	42 07	83:06	75															1		
AMHERSTBURG	210 BALACLAVA	12092	4	I	42.07	83 06	75															1		
AMHERSTBURG	208-210 ALMA STREET	12095	4	I	42:06	83 06	75															1		
BLENHEIM	ST. MARY'S PUBLIC SCHOOL	13009	3	I	42 20	83 00	93	1																
COURTRIGHT	CON RD. 14 (E OF RWY TRACK)	14004	4	I	42:45	82:27	71															1		
LONDON	POND MILLS RD /DEVERON CRES	15014	5	I	42 57	81:12	86	1	1		1	1	1	1		1	1	1	1					As,Be,Sb,Li,Sn,Ti,Se
LONDON	951 COMMISSIONERS RD. EAST	15015	4	I	42 58	81:13	86	1	1		1	1	1	1		1	1	1	1					As,Be,Sb,Li,Sn,Ti,Se
LONDON	801 COMMISSIONERS RD. EAST	15016	4	I	42.57	81:13	86	1	1		1	1	1	1		1	1	1	1					As,Be,Sb,Li,Sn,Ti,Se
LONDON	8 MOUNTSFIELD DRIVE	15017	4	I	42 58	81:15	86	1	1		1	1	1	1		1	1	1	1					As,Be,Sb,Li,Sn,Ti,Se
INGERSOLL	CARNEGIE/BRUCE STREET	17007	4	I	43:02	80:53	77															1		
INGERSOLL	PEMBERTON ST. (CIL ENTRANCE)	17009	4	I	43.03	80:52	77															1		
NANTICOKE	LAUREK	22057	4	I	42 41	80 24	72															1		
NANTICOKE	NANTICOKE ROAD	22070	4	I	42 48	80 05	74	1														1	1	
NANTICOKE	IMPERIAL OIL PROPERTY	22074	4	I	42.49	80 03	75															1		
JARVIS	HWY 6/QUARTERLINE ROAD	22083	4	I	42:48	80:09	74															1		
SIMCOE	94 SECOND AVENUE	22105	4	I	42:50	80 18	93	1														1	1	
SIMCOE	DAVIS/SPRUCE ST	22107	4	I	42.51	80:18	93	1														1		
NANTICOKE	NANTICOKE RD/WALPOLE CON 2	22961	3	I	42:49	80:04	86															1		
CHIPPAWA	7961 PORTAGE ROAD	27005	5	I	43.03	70.03	73	1																
WELLAND	474 HARRIET STREET	27025	5	I	42:58	79:14	71	1																
WELLAND	228 CHAFFEY STREET	27026	5	I	42 58	79.14	71	1																
WELLAND	383 ALBERTA STREET	27035	5	I	42:58	79 14	75	1																
ST CATHARINES	37 PLYMOUTH AVENUE	27040	4	I	43:10	79.13	78	1															1	
ST CATHARINES	GLENDALE AV/QEW	27041	4	I	43 09	79.11	78	1															1	
ST CATHARINES	GM FOUNDRY	27063	4	I	43:08	79:11	86	1															1	
NIAGARA FALLS	7525 WANLESS ST	27073	4	I	43:06	79.07	93	1															1	
NIAGARA FALLS	5407 HODGSON AVE	27074	4	I	43:05	79.07	93	1															1	
THOROLD	TOWNLINE RD	27075	2	I	43:06	79 11	93	1																
THOROLD	BEAVERSDAM RD/THOROLD LINE	27076	4	I	43 06	79.11	93	1																
HAMILTON	HUGHSON/HUNTER	29001	9	I	43:15	79:52	61	1	1	1	1	1	1	1		1	1	1	1			1		Mo
HAMILTON	QUEENSTON	29006	5	I	43:14	79 48	61	1																
HAMILTON	KENILWORTH	29009	6	I	43 15	79 49	69	1																
HAMILTON	OTTAWA/BURLINTON	29010	5	I	43 15	79 49	61	1	1	1	1	1	1	1		1	1	1	1					Mo
HAMILTON	BURLINGTON/LEEDS	29011	5	I	43.16	79 49	66	1															1	
HAMILTON	BURLINGTON/WELLINGTON	29012	7	I	43.16	79 59	69	1														1		
HAMILTON	BARTON/WENTWORTH	29025	4	I	43 16	79 15	70	1														1	1	
HAMILTON	ROOSEVELT/BEACH	29036	5	I	43:15	79 48	70	1	1	1	1	1	1	1		1	1	1	1					Mo
HAMILTON	312 BEACH BLVD.	29044	5	I	43 16	79.46	70	1																
HAMILTON	BEACH/CONRAD	29054	3	I	43:15	79 48	70															1		
HAMILTON	BURL/GAGE PUMPING STATION	29059	5	I	43.16	79:49	70															1		
HAMILTON	BRIARWOOD VOC SCHOOL	29062	8	I	43:16	79 48	70															1		
HAMILTON	KILLARNEY ST. (POLE #2)	29066	5	I	43:17	79 47	73															1		
GREENSVILLE	KANE/HYLTON RESIDENCE	29074	5	I	43 17	79:58	74	1															1	
GREENSVILLE	MELDRUM/WESTIE STREETS	29076	5	I	43:17	79:15	74	1																
HAMILTON	1190 LEASIDE ROAD	29082	4	I	43 15	79:46	77	1																

TABLE C-3

ONTARIO AIR MONITORING NETWORK FOR 1994, MONTHLY DATA

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TYP = A:AMBIENT SURVEY; I:SOURCE SPECIFIC SURVEY
ELEV = AIR INTAKE HEIGHT ABOVE GROUND (METERS)
LAT = LATITUDE (DEGREES:MINUTES)
LONG = LONGITUDE (DEGREES:MINUTES)

CITY	STATION NAME	ID	ELEV (M)	TYPE	LAT	LONG	YR	TDF	Cd	Co	Cr	Cu	Fe	Mn	Na	Ni	Pb	Y	Zn	NO3	SO4	FLR	OM	OTHERS
HAMILTON	REMBE/BEACH BLVD	29084	4	I	43.17	79.47	79	1															1	
HAMILTON	OFIELD ROAD (MAYS PROPERTY)	29096	4	I	43.18	79.59	82	1																
GREENSVILLE	4TH CONCESSION ROAD	29097	4	I	43.18	79.59	82	1																
HAMILTON	467 BEACH BLVD	29102	4	I	43.17	79.47	85	1	1	1	1	1	1	1		1	1	1	1					Mo
HAMILTON	LONDON/JUSTINE (NW CORNER)	29115	4	I	43.14	79.49	88															1		
HAMILTON	DALKEITH/OTTAWA	29116	4	I	43.15	79.49	86															1		
HAMILTON	MORLEY ST/PARKDALE AV.	29119	4	I	43.15	79.47	86															1		
HAMILTON	12 DICKSON STREET	29120	4	I	43.16	79.50	86															1		
HAMILTON	ROSSLYN/MONTCLAIR, NE CORNER	29126	4	I	43.14	79.49	88															1		
HAMILTON	LAWRENCE/BALMORAL	29127	4	I	43.14	79.49	88															1		
HAMILTON	PROVINCE/JUSTINE	29129	4	I	43.13	79.49	88															1		
HAMILTON	CENTRAL/GRAHAM (NW CORNER)	29131	4	I	43.14	79.49	88															1		
HAMILTON	KENORA/KEEFER CT	29142	4	I	43.24	79.76	92	1																
HAMILTON	KEEFER COURT	29143	4	I	43.24	79.76	92	1																
HAMILTON	CAROLINE/BARTON ST.	29145	4	I	43.16	79.52	93	1									1							Mo
HAMILTON	STUART ST.	29146	4	I	43.16	79.52	93	1									1							Mo
HAMILTON	CHATHAM/FANNING	29217	4	I	43.15	79.53	87	1																
HAMILTON	80 CAMEO AVE. (POLE IN FRONT)	29230	4	I	43.13	79.51	87	1	1	1	1	1	1	1		1	1	1	1					Mo
HAMILTON	8 AUDREY AVE. (POLE IN FRONT)	29231	4	I	43.14	79.51	87	1																
GREENSVILLE	OLFIELD RD. S/HWY 5	29273	4	I	43.17	79.59	88	1															1	
TORONTO	661 EASTERN AVENUE	31019	5	I	43.39	79.20	70	1									1							
TORONTO	MOSLEY/LESLIE STREETS	31058	5	I	43.40	79.20	75	1									1							
TORONTO	RUSHBROOKE/EASTERN AVENUE	31059	4	I	43.39	79.20	73	1									1							
TORONTO	LESLIE/QUEEN STREET EAST	31060	4	I	43.40	79.20	73	1									1							
TORONTO	633 EASTERN AVENUE	31065	12	I	43.40	79.20	87	1									1							
TORONTO	WORKS DEPT.,138 HAMILTON AVE	31082	5	I	43.40	79.21	74	1									1							
ETOBICOKE	70 JUDSON STREET	35016	5	I	43.37	79.30	88	1																
ETOBICOKE	60 JUDSON STREET	35017	5	I	43.37	79.30	88	1																
ETOBICOKE	JUDSON STREET	35018	5	I	43.37	79.30	88	1																
YORK	425A GILBERT AVENUE	36028	3	I	43.41	79.27	86	1																
OAKVILLE	2487 LAKESHORE E/BIRBANK RDS	44005	2	I	43.29	79.38	71	1																
BURLINGTON	5223 HWY5	44100	5	I	43.25	79.48	78															1		
BURLINGTON	5236 HWY5	44101	1	I	43.25	79.48	86															1		
BURLINGTON	2282 ORCHARD ROAD	44102	1	I	43.24	79.48	86															1		
BURLINGTON	LAIDLAW BUS YARD/HWY 5	44103	5	I	43.25	79.48	89															1		
BURLINGTON	HARRISON CT (N END)	44105	5	I	43.24	79.48	89															1		
BOWMANVILLE	2 LAKE DRIVE	45042	5	I	43.53	78.40	88	1																
BOWMANVILLE	36 CEDARCREST BEACH	45044	1	I	43.53	78.40	88	1																
BOWMANVILLE	COVE ROAD (HYDRO POLE)	45045	4	I	43.53	78.40	90	1																
MISSISSAUGA	SOUTHDOWN/ORR ROADS	46029	5	I	43.30	79.37	71	1																
MISSISSAUGA	1801 ORR STREET	46099	5	I	43.30	79.37	77	1																
MISSISSAUGA	QUEEN/MATLOCK STREET	46105	5	I	43.35	79.43	78															1		
MISSISSAUGA	BRITTANIA ROAD W/PIONEER ST.	46106	5	I	43.35	79.43	78															1		
MISSISSAUGA	MEADOW PARK, APPLE LANE CLUB	46117	5	I	43.31	79.36	87	1	1	1	1	1	1	1		1	1	1	1			1		Mo
BRAMPTON	WANLESS DRIVE (HYDRO POLE#68)	46120	5	I	43.43	79.49	88															1		
BRAMPTON	HIGHWAY 10 (HYDRO POLE #3188)	46121	5	I	43.42	78.34	88															1		
BRAMPTON	HUNTLEY PK/SANDALWOOD PKWY.	46123	5	I	43.43	79.48	88															1		
FORT FRANCES	CEMETERY, COLONIZATION RD. W	62032	5	I	48.37	93.25	74	1							1						1			
FORT FRANCES	NELSON STREET/PORTAGE AVE.	62033	4	I	48.36	93.23	74	1							1						1			
FORT FRANCES	FIRST STREET/VICTORIA AVENUE	62034	4	I	48.36	93.23	74	1							1						1			
FORT FRANCES	LEGION BUILDING,250 CHURCH ST	62035	9	I	48.36	93.23	74	1							1						1			
FORT FRANCES	SINCLAIR ST/VICTORIA AVENUE	62036	4	I	48.36	93.23	74	1							1						1			
FORT FRANCES	REID AVENUE/GILLON STREET	62037	4	I	48.36	93.22	76	1							1						1			
FORT FRANCES	308 SINCLAIR STREET	62046	4	I	48.36	93.23	78	1							1						1			
FORT FRANCES	319 NELSON STREET	62050	3	I	48.36	93.23	82	1							1						1			

TABLE C-3

ONTARIO AIR MONITORING NETWORK FOR 1994, MONTHLY DATA

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TYP = A:AMBIENT SURVEY; I:SOURCE SPECIFIC SURVEY
ELEV = AIR INTAKE HEIGHT ABOVE GROUND (METERS)
LAT = LATITUDE (DEGREES:MINUTES)
LONG = LONGITUDE (DEGREES:MINUTES)

CITY	STATION NAME	ID	ELEV (M)	TYPE	LAT	LONG	YR	TDF	Cd	Co	Cr	Cu	Fe	Mn	Na	Ni	Pb	V	Zn	NO3	SO4	FLR	OM	OTHERS
THUNDER BAY	CAN-CAR, MONTREAL STREET	63046	3	I	48 21	89 18	78	1							1						1			
THUNDER BAY	TOTEM TRAILER PK, HWY 61B	63047	4	I	48 35	83 30	77	1							1						1			
SAULT STE MARIE	PITTSBURGH/YOUNG STS	71015	5	A	46 31	84 23	70	1																
SAULT STE MARIE	PUMPHOUSE, BONNEY STREET	71042	4	I	46 31	84 23	75	1															1	
SAULT STE MARIE	WILDING/WALLACE TERRACE	71043	5	I	46 31	84 22	75	1																
SAULT STE MARIE	73 ADELAIDE STREET	71045	5	A	46:31	84 21	75	1																
SAULT STE MARIE	FAIRVIEW AVENUE	71046	5	A	46.33	84:21	75	1																
HEARST	SECOND/FRONT STS (HYDRO PLE)	72018	4	I	49 41	83:38	76	1																
TIMMINS	GILLIES STREET	72026	5	A	48 28	81:21	91	1																
TIMMINS	WAFERBOARD PLANT, HGHWY. 101	72034	5	A	48:26	81:27	91	1																
KAPUSKASING	2 MCPHERSON AVENUE	72060	4	I	49 24	82 25	80	1																
KAPUSKASING	4 RIVERSIDE DRIVE	72061	4	I	49 24	82:25	80	1																
HEARST	CUSTOM SAWMILL RD(LEBLANC)	72080	5	I	49 41	83.38	84	1																
HEARST	HIGHWAY 11/HIGHWAY 583	72082	6	A	49 41	83.38	84	1																
COCHRANE	3RD STREET/16TH AVENUE	72086	3	I	49 03	81:00	86	1																
HEARST	HIGHWAY 11,W OF MATTISKWIA R.	72091	3	I	49 41	83:37	87	1																
ENGLEHART	KAP-KIG-IWAN ROAD	72102	3	I	47.49	79:53	94	1																
ENGLEHART	KING STREET	72103	3	I	47.50	79.53	94	1																
ENGLEHART	FIFTH AVENUE	72104	3	I	47:50	79:53	94	1																
SOUTH PORCUPINE	CHARLES/WARNER	72105	5	I	48 28	81:13	94	1																
HEARST	ALLEN/FONTAINE	72106	4	I	49 01	83:19	94	1																
TOTALS:								89	10	6	10	10	10	10	10	10	18	10	10	0	10	44	13	

LEGEND:

TDF - Total Dustfall
Cd - Cadmium
Co - Cobalt
Cr - Chromium
Cu - Copper
Fe - Iron
Mn - Manganese
Na - Sodium

Ni - Nickel
Pb - Lead
V - Vanadium
Zn - Zinc
NO3 - Nitrate
SO4 - Sulphate
FLR - Fluoridation Rate
OM - Optical Microscopy

OTHERS:

As - Arsenic
Be - Beryllium
F - Soluble Fluorides
K - Potasium
Li - Lithium
Mg - Magnesium

Mo - Molybdenum
Sb - Antimony
Se - Selenium
Sn - Tin
Ti - Titanium
U - Uranium
Id - Ident

TABLE C-4

ONTARIO INHALABLE PARTICULATE NETWORK FOR 1994.

ID - STATION ID; YR - YEAR MONITORING BEGAN; LAT - LATITUDE(DEGREES:MINUTES); LONG - LONGITUDE(DEGREES:MINUTES)
ELEV - AIR INTAKE HEIGHT ABOVE GROUND (METERS)

CITY	STATION NAME	ID	YR	LAT	LONG	ELEV (M)	IP	Cu	Fe	Mn	Pb	Cr	Cd	V	NI	Zn	Ca	Ti	Br	Rb	Sr	Zr	Ba	Se	As	SO4
WINDSOR	WRIGHT/WATER STREET	12507	90	42:17	82 16	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
WINDSOR	467 UNIVERSITY AVE WEST	12508	89	42:19	83:02	8	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
WINDSOR	3665 WYANDOTTE ST. E.	12513	92	42:19	83 00	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
LONDON	801 COMMISSIONERS RD. E.	15516	90	42 57	81 13	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
NANTICOKE	WALPOLE S P.S , SANDUSK RD	22304	92	42:50	80 02	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
ST CATHARINES	KING ST	27308	91	43.10	79 15	12	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
THOROLD	185 QUEEN ST SOUTH	27352	90	43:07	79 12	1	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
HAMILTON	ELGIN\KELLY STREET	29300	90	43.15	79.52	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
HAMILTON	BEACH BLVD	29302	89	43:17	79 47	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
HAMILTON	GERTRUDE/DEPEW STREET	29313	90	43 15	79 49	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
HAMILTON	BUCHANAN PARK P S.	29324	92	43 14	79 53	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
TORONTO	BAY ST./GROSVERNOR AVE	31127	89	43 40	79 23	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
MISSISSAUGA	MEADOW PK, APPLE LANE C C	46127	93	43 31	79 36	1	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
CORNWALL	MEMORIAL PK, BEDFORD/THIRD STS	56051	92	45.01	74 44	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
FORT FRANCES	250 CHURCH STREET	62135	92	48 36	93 23	9	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
THUNDER BAY	615 JAMES ST. SOUTH	63201	89	48 23	89 17	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
SAULT STE MARIE	PUMPHOUSE,BONNEY STREET	71342	89	46:31	84 23	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
SAULT STE MARIE	W M MERRIFIELD SCHOOL	71368	90	46 32	84 21	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
SUDBURY	LISGAR ST	77326	91	46 29	80 59	8	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
TOTALS:						19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19

Notes Samplers operate on a 6-day sampling cycle

LEGEND:

IP - Inhalable Particulate
Cu - Copper
Fe - Iron
Mn - Manganese
Pb - Lead

Cr - Chromium
Cd - Cadmium
V - Vandium
Ni - Nickel
Zn - Zinc

Ca - Calcium
Ti - Titanium
Br - Bromine
Rb - Rubidium
Sr - Strontium

Zr - Zirconium
Ba - Barium
Se - Selenium
As - Arsenic
SO4 - Sulphate

TABLE C-5

ONTARIO METEOROLOGICAL NETWORK FOR 1994, HOURLY DATA

ID - STATION ID NUMBER YR - YEAR MONITORING BEGAN LAT - LATITUDE (DEGREES:MINUTES)
T - TELEMETRY L - DATA LOGGER

CITY	STATION NAME	ID	YR	LAT	LONG	WS1	HT1	WS2	HT2	WS3	HT3	TEM	DT1	DT2
WINDSOR	WRIGHT/WATER ST.	12007	84	42:17	82:16	T	10	T	40			T	T	
MERLIN	MOE WATER PUMP STN, MIDDLE RD.	13021	77	42.15	82.13	T	9							
COURTRIGHT	HWY 40 (OPP LAMBTON GS)	14016	75	42:48	82 29	T	10	T	30	T	90	T	T	T
PARKHILL	PUC BUILDING	15013	83	43.10	81 41	T	10							
LONDON	800 COMMISSIONERS ST. (EFW PLANT)	15018	86	42 57	81 13	L	25							
BEACHVILLE	26 VINE STREET (MOE TRAILER)	17015	89	43.04	80 51	T	9							
TIVERTON	BRUCE GS WEATHER STATION	18017	94	44:18	81:35	T	10	T	30			T	T	T
JARVIS	HYDRO MET TOWER (2KM NE JARVIS)	22883	84	42.54	80.05	T	10			T	85	T		
LONG POINT	PROVINCIAL PARK	22901	79	42.35	80 23	T	10			T	85	T		
NANTICOKE	RAINHAM ROAD (NEAR STELCO GATE)	22907	89	42:48	80.04	T	10							
CAMBRIDGE	CLYDE ROAD	26066	91	43:38	80:29	T	30							
ELMIRA	PARK/DUKE	26069	93	43:35	80:30	T	10							
ALLANBURG	TRANSFORMER STATION HIGHWAY 58	27011	81	43 04	79.11	T	10	T	37			T	T	
HAMILTON	BRAMPTON/WOODWARD	29026	75	43:15	79.46	T	10	T	30	T	91	T	T	T
TORONTO	ISLAND AIRPORT-ENVIRONMENT CANADA SITE	31025	75	43:38	79 23	T	10							
TORONTO	BRUCE PS, 51 LARCHMOUNT AVENUE	31045	75	43.39	79.25	T	21							
TORONTO	PERTH/RUSKIN (JUNCTION TRIANGLE)	31120	82	43 40	79 27	T	18							
SCARBOROUGH	LAWRENCE/KENNEDY AVE.	33003	75	43 45	79 16	T	12			T	76	T	T	
ETOBICOKE	EVANS/ARNOLD AVENUE	35033	75	43.37	79 31	T	10	T	30	T	91	T	T	T
OAKVILLE	BRONTE ROAD/WOBURN CRESCENT	44015	80	43 24	79 44	T	10							
OSHAWA	PUBLIC SCHOOL, RITSON RD/OLIVE AVE.	45025	79	43.53	78.51	T	10							
STOUFFVILLE	HIGHWAY 47 EAST OF HIGHWAY 48	48002	82	43:58	79:16	T	10							
CORNWALL	861 WEST SECOND STREET	56065	76	45.01	74.44	T	10							
DRYDEN	35 VAN HORNE AVENUE	61027	84	49:47	92:50	T	18					T		
FORT FRANCES	EIGHTH STREET/CORNWALL AVENUE	62047	90	48 37	93:25	T	10					T		
MARATHON	WATER TOWER	63033	78	48.43	86:23	T	8							
RED ROCK	RECREATION CENTRE	63084	82	48 57	88 15	T	15							
TERRACE BAY	ST MARTIN SCHOOL	63090	81	48 47	87.05	T	12					T		
THUNDER BAY	MTO 615 JAMES STREET SOUTH	63200	90	48 22	89:17	T	10							
SAULT STE MARIE	WM. MERRIFIELD SCHOOL	71068	87	46 32	84.21	T	10					T		
NORTH BAY	OPP STATION	75010	87	46.19	79.27	T	10					T		
SUDBURY	HANMER	77013	82	46.39	80.57	T	10					T		
SUDBURY	CKNC-TV, 699 FROOD ROAD	77025	73	46:30	81:00	T	10			T	115	T		T
SUDBURY	1412 STEPHEN STREET	77225	90	46 28	81:00	T	6					T		

LEGEND:

WS1 - WIND SPEED AND DIRECTION BELOW 23 M
WS2 - WIND SPEED AND DIRECTION 23 M TO 76 M
WS3 - WIND SPEED AND DIRECTION ABOVE 76 M
TEM - AMBIENT TEMPERATURE
DT1 - TEMPERATURE DIFFERENCE LEVEL 2 MINUS LEVEL 1
DT2 - TEMPERATURE DIFFERENCE LEVEL 3 MINUS LEVEL 1

HT1 - SENSOR HEIGHT (METERS) LEVEL 1
HT2 - SENSOR HEIGHT (METERS) LEVEL 2
HT3 - SENSOR HEIGHT (METERS) LEVEL 3

TABLE C-6

SULPHUR DIOXIDE (SO2) STATISTICS (1994)

UNIT = PARTS/MILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES						ARITH. MEAN	MAXIMUM		NO. OF TIMES ABOVE CRITERIA		
				10	30	50	70	90	99		1 h	24 h	1 h	24 h	1 Yr
12007	WRIGHT/WATER ST	WINDSOR	363	0.000	0.000	0.002	0.007	0.015	0.037	0.008	0.09	0.04	0	0	0
12008	467 UNIVERSITY AV W	WINDSOR	363	0.000	0.000	0.000	0.005	0.012	0.033	0.006	0.14	0.02	0	0	0
12016	COLLEGE/SOUTH ST	WINDSOR	356	0.000	0.000	0.000	0.005	0.013	0.030	0.006	0.12	0.02	0	0	0
14016	HWY40 (OPP LAMBTON GS)	COURTRIGHT	363	0.000	0.000	0.000	0.000	0.009	0.039	0.004	0.18	0.04	0	0	0
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	362	0.000	0.000	0.000	0.002	0.020	0.108	0.009	0.20	0.10	0	0	0
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	361	0.000	0.000	0.000	0.002	0.008	0.017	0.004	0.06	0.02	0	0	0
15015	951 COMMISSIONERS RD E	LONDON	337	0.000	0.000	0.000	0.000	0.000	0.010	0.001	0.04	0.02	0	0	0
15016	801 COMMISSIONERS RD E	LONDON	337	0.000	0.000	0.000	0.000	0.003	0.012	0.002	0.04	0.02	0	0	0
15017	8 MOUNTSFIELD DR	LONDON	337	0.000	0.000	0.000	0.000	0.001	0.010	0.001	0.07	0.02	0	0	0
18007	CONCESSION RD 2 LOT A	TIVERTON	362	0.000	0.000	0.000	0.000	0.003	0.012	0.002	0.05	0.01	0	0	0
22071	EXPERIMENTAL FARM	SIMCOE	358	0.000	0.000	0.000	0.000	0.006	0.019	0.002	0.05	0.03	0	0	0
22086	CHEAPSIDE RD(3 KM S OF HWY 3)	NANTICOKE	327	0.000	0.000	0.000	0.002	0.010	0.033	0.005	0.13	0.03	0	0	0
22094	TOWNLINE RD/CON 13	TOWNSEND	326	0.000	0.000	0.000	0.000	0.008	0.021	0.003	0.10	0.02	0	0	0
22901	PROVINCIAL PARK	LONG POINT	330	0.000	0.000	0.000	0.000	0.007	0.019	0.003	0.06	0.02	0	0	0
22907	RAINHAM RD (NEAR STELCO GATE)	NANTICOKE	343	0.000	0.000	0.000	0.002	0.012	0.049	0.006	0.19	0.04	0	0	0
26060	WEST AVE/HOMEWOOD	KITCHENER	361	0.000	0.000	0.000	0.000	0.007	0.018	0.003	0.04	0.02	0	0	0
26069	PARK/DUKE	ELMIRA	344	0.000	0.000	0.000	0.000	0.007	0.050	0.004	0.17	0.03	0	0	0
27067	ARGYLE CRES (PUMP STN)	ST CATHARINES	352	0.000	0.000	0.000	0.000	0.007	0.021	0.003	0.04	0.03	0	0	0
27072	STANLEY AVE/HWY 420	NIAGARA FALLS	357	0.000	0.000	0.000	0.000	0.008	0.024	0.003	0.06	0.02	0	0	0
29000	ELGIN/KELLY ST	HAMILTON	360	0.000	0.000	0.000	0.002	0.010	0.037	0.005	0.09	0.03	0	0	0
29025	BARTON/WENTWORTH	HAMILTON	356	0.000	0.000	0.000	0.003	0.014	0.044	0.006	0.13	0.03	0	0	0
29102	467 BEACH BLVD	HAMILTON	351	0.000	0.000	0.000	0.007	0.026	0.068	0.010	0.16	0.05	0	0	0
29105	NASH RD/KENTLEY DR	HAMILTON	357	0.000	0.000	0.000	0.000	0.007	0.019	0.003	0.06	0.02	0	0	0
29114	VICKERS RD/EAST 18TH ST	HAMILTON	359	0.000	0.000	0.000	0.003	0.014	0.036	0.006	0.08	0.04	0	0	0
29118	MAIN ST W/HWY403	HAMILTON	362	0.000	0.000	0.000	0.002	0.009	0.025	0.004	0.08	0.03	0	0	0
29561	HAMILTON - HOMESIDE	HAMILTON	155	0.000	0.000	0.000	0.004	0.010	0.036	INS	0.09	0.02	0	0	INS
31103	BAY/GROSVENOR	TORONTO	361	0.000	0.000	0.000	0.000	0.007	0.019	0.003	0.06	0.03	0	0	0
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	303	0.000	0.000	0.000	0.002	0.008	0.020	0.004	0.07	0.03	0	0	0
33003	LAWRENCE/KENNEDY	SCARBOROUGH	355	0.000	0.000	0.000	0.000	0.007	0.018	0.003	0.05	0.03	0	0	0
34020	HENDON AVE (YONGE/FINCH)	NORTH YORK	356	0.000	0.000	0.000	0.000	0.007	0.021	0.003	0.06	0.03	0	0	0
35003	ELMCREST RD (CENTENNIAL PK)	ETOBICOKE	359	0.000	0.000	0.000	0.001	0.008	0.021	0.004	0.08	0.02	0	0	0
35033	EVANS/ARNOLD AV	ETOBICOKE	360	0.000	0.000	0.000	0.001	0.008	0.020	0.004	0.07	0.03	0	0	0
36030	CLEARVIEW HTGS/KEELE ST	YORK	353	0.000	0.000	0.000	0.001	0.008	0.019	0.004	0.06	0.02	0	0	0
44008	HWY2/NORTH SHORE BLVD E	BURLINGTON	356	0.000	0.000	0.000	0.001	0.008	0.020	0.004	0.07	0.02	0	0	0
44015	BRONTE RD/WOBURN CRES	OAKVILLE	356	0.000	0.000	0.000	0.001	0.009	0.027	0.004	0.22	0.03	0	0	0
45025	PS, RITSON RD/OLIVE AV	OSHAWA	360	0.000	0.000	0.000	0.000	0.006	0.021	0.002	0.05	0.03	0	0	0
46110	QUEENSWAY W/HURONTARIO ST	MISSISSAUGA	361	0.000	0.000	0.000	0.000	0.007	0.019	0.003	0.05	0.02	0	0	0
46117	MEADOWOOD PARK	MISSISSAUGA	357	0.000	0.000	0.000	0.000	0.006	0.019	0.003	0.09	0.02	0	0	0
48002	HWY47/E OF HWY48	STOUFFVILLE	361	0.000	0.000	0.000	0.001	0.008	0.018	0.004	0.05	0.02	0	0	0
51001	MCD GDS, RIDEAU/WURTEMBURG ST	OTTAWA	364	0.000	0.000	0.000	0.000	0.000	0.013	0.001	0.08	0.02	0	0	0
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	363	0.000	0.000	0.000	0.007	0.028	0.093	0.012	0.49	0.08	3	0	0
63200	MTC 615 JAMES ST S	THUNDER BAY	361	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.02	0.01	0	0	0
71068	WM. MERRIFIELD SCHOOL	SAULT STE MARIE	355	0.000	0.000	0.000	0.000	0.001	0.026	0.002	0.11	0.02	0	0	0
71077	SUPERIOR AVE/TAMARACK AVE	WAWA	47	0.000	0.000	0.000	0.000	0.000	0.164	INS	0.40	0.05	8	0	INS
77012	SKEAD	SUDBURY	360	0.000	0.000	0.000	0.000	0.007	0.113	0.006	0.40	0.07	15	0	0
77013	HANMER	SUDBURY	358	0.000	0.000	0.000	0.000	0.002	0.049	0.003	0.56	0.05	1	0	0
77016	WATER TANK, ASH ST	SUDBURY	360	0.000	0.000	0.000	0.000	0.009	0.073	0.005	0.43	0.06	7	0	0
77028	GOVERNMENT RD/EDWARD ST	CONISTON	358	0.000	0.000	0.000	0.000	0.005	0.066	0.004	0.35	0.05	3	0	0
77065	FALCONBRIDGE RD	GARSON	361	0.000	0.000	0.000	0.000	0.004	0.058	0.003	0.42	0.06	2	0	0
77075	KENNEDY ST	NEW SUDBURY	361	0.000	0.000	0.000	0.000	0.006	0.069	0.004	0.29	0.04	1	0	0
77096	LONG LAKE RD (VILLA LOYOLA)	SUDBURY	359	0.000	0.000	0.000	0.000	0.004	0.077	0.004	0.45	0.07	2	0	0
77201	MIKKOLA (J. HAMILTON SCHOOL)	SUDBURY	354	0.000	0.000	0.000	0.000	0.000	0.041	0.002	0.49	0.08	5	0	0
77203	SCIENCE NORTH	SUDBURY	346	0.000	0.000	0.000	0.000	0.006	0.050	0.003	0.49	0.04	2	0	0
77206	ST LAURENT/REGIONAL RD	RAYSIDE	360	0.000	0.000	0.000	0.000	0.000	0.023	0.001	0.26	0.03	1	0	0
77218	LOT 2-PLAN M-1025	COPPER CLIFF	360	0.000	0.000	0.000	0.000	0.008	0.088	0.005	0.83	0.08	14	0	0
77225	1412 STEPHEN STREET	SUDBURY	360	0.000	0.000	0.000	0.000	0.006	0.075	0.004	0.51	0.06	14	0	0
77228	MARY-GLOVER ST (PARK)	SUDBURY	197	0.000	0.000	0.000	0.000	0.006	0.062	INS	0.26	0.05	1	0	INS

TABLE C-7 SUSPENDED PARTICLES (SP) STATISTICS (1994)

UNIT = COHS/1000 FT

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	24 h	NO. OF TIMES ABOVE CRITERIA 24 h	1 Yr
12008	467 UNIVERSITY AV W	WINDSOR	360	0.03	0.12	0.18	0.27	0.58	1.07	0.28	4.7	1.9	1	0
12016	COLLEGE/SOUTH ST	WINDSOR	360	0.05	0.15	0.23	0.34	0.37	1.57	0.35	4.1	1.8	3	0
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	362	0.00	0.05	0.12	0.20	0.45	0.74	0.20	2.4	0.8	0	0
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	351	0.00	0.06	0.13	0.23	0.48	1.17	0.25	3.2	1.5	1	0
22907	RAINHAM RD (NEAR STELCO GATE)	NANTICOKE	325	0.01	0.08	0.16	0.28	0.45	0.84	0.26	4.9	0.8	0	0
26060	WEST AVE/HOMEWOOD	KITCHENER	362	0.01	0.08	0.15	0.25	0.39	1.07	0.25	2.8	1.2	1	0
26069	PARK/DUKE	ELMIRA	349	0.00	0.05	0.11	0.20	0.44	0.84	0.21	2.1	0.9	0	0
27067	ARGYLE CRES (PUMP STN)	ST CATHARINES	357	0.01	0.08	0.15	0.25	0.57	0.98	0.25	2.7	0.9	0	0
27072	STANLEY AVE/HWY 420	NIAGARA FALLS	343	0.03	0.14	0.25	0.37	0.95	0.90	0.33	2.3	0.9	0	0
29000	ELGIN/KELLY ST	HAMILTON	361	0.06	0.18	0.29	0.47	1.09	2.02	0.47	3.7	1.8	17	0
29001	HUGHSON/HUNTER	HAMILTON	280	0.07	0.22	0.36	0.56	1.01	2.35	0.54	4.6	2.8	24	1
29025	BARTON/WENTWORTH	HAMILTON	356	0.10	0.24	0.39	0.57	1.10	2.10	0.54	4.0	2.2	21	1
29102	467 BEACH BLVD	HAMILTON	351	0.06	0.25	0.46	0.70	0.75	2.13	0.59	3.6	2.1	25	1
29105	NASH RD/KENTLEY DR	HAMILTON	353	0.16	0.26	0.35	0.46	0.53	1.61	0.47	3.7	1.7	6	0
29114	VICKERS RD/EAST 18TH ST	HAMILTON	361	0.01	0.09	0.17	0.28	0.84	1.23	0.28	2.6	1.2	1	0
29118	MAIN ST W/HWY403	HAMILTON	361	0.02	0.11	0.21	0.36	0.82	1.77	0.38	2.9	1.8	13	0
29561	HAMILTON - HOMESIDE	HAMILTON	81	0.04	0.17	0.28	0.42	0.99	1.75	INS	3.9	1.3	3	INS
31049	MISSION, 381 YONGE ST	TORONTO	248	0.11	0.25	0.39	0.58	0.69	1.87	0.54	3.4	1.6	13	1
31103	BAY/GROSVENOR	TORONTO	358	0.04	0.16	0.27	0.41	0.60	1.32	0.38	2.5	1.5	3	0
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	303	0.03	0.13	0.21	0.33	0.61	1.29	0.33	2.9	1.0	0	0
33003	LAWRENCE/KENNEDY	SCARBOROUGH	355	0.03	0.13	0.23	0.35	0.79	1.34	0.34	4.5	2.5	2	0
34020	HENDON AVE (YONGE/FINCH)	NORTH YORK	354	0.02	0.14	0.27	0.44	0.75	1.49	0.40	2.7	1.8	6	0
35003	ELMCREST RD (CENTENNIAL PK)	ETOBICOKE	357	0.04	0.13	0.22	0.37	0.92	1.84	0.38	3.2	1.9	6	0
35033	EVANS/ARNOLD AV	ETOBICOKE	357	0.07	0.21	0.34	0.51	0.78	1.88	0.49	4.7	2.7	12	0
36030	CLEARVIEW HTGS/KEELE ST	YORK	356	0.05	0.16	0.26	0.40	0.63	1.92	0.41	4.1	2.6	7	0
44008	HWY2/NORTH SHORE BLVD E	BURLINGTON	354	0.02	0.12	0.22	0.35	0.66	1.45	0.34	3.4	1.8	2	0
44015	BRONTE RD/WOBURN CRES	OAKVILLE	360	0.02	0.12	0.21	0.35	0.71	1.49	0.34	2.8	1.6	2	0
45025	PS, RITSON RD/OLIVE AV	OSHAWA	346	0.02	0.12	0.23	0.38	0.78	1.58	0.37	4.1	1.8	7	0
46110	QUEENSWAY W/HURONTARIO ST	MISSISSAUGA	360	0.04	0.16	0.28	0.43	0.40	1.70	0.41	3.8	1.5	3	0
51001	MCD GDS, RIDEAU/WURTEMBURG ST	OTTAWA	356	0.00	0.06	0.12	0.20	0.85	0.90	0.22	1.8	0.9	0	0
52020	CHURCHILL PK, NAPIER ST	KINGSTON	360	0.01	0.09	0.17	0.29	0.37	2.18	0.37	3.6	1.7	8	0
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	357	0.00	0.03	0.08	0.16	0.42	1.06	0.19	3.8	1.2	1	0
62030	PORTAGE/CHURCH ST	FORT FRANCES	360	0.00	0.04	0.10	0.19	0.41	0.92	0.21	2.0	0.8	0	0
63046	CAN-CAR, MONTREAL ST	THUNDER BAY	347	0.00	0.00	0.05	0.16	0.51	0.99	0.17	2.4	1.0	0	0
63200	MTC 615 JAMES ST S	THUNDER BAY	346	0.00	0.05	0.00	0.23	0.60	1.34	0.25	3.3	1.2	3	0
71068	WM. MERRIFIELD SCHOOL	SAULT STE MARIE	334	0.00	0.06	0.00	0.29	0.40	1.35	0.29	2.6	1.1	1	0
75010	OPP STN NORTH BAY	SUDBURY	333	0.00	0.03	0.00	0.16	0.35	1.02	0.19	2.4	0.8	0	0
77203	SCIENCE NORTH	SUDBURY	339	0.00	0.04	0.00	0.18	0.08	0.83	0.19	2.5	0.7	0	0

TABLE C-8

TOTAL REDUCED SULPHUR (TRS) STATISTICS (1994)

UNIT = PARTS/BILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	24 h	EXCEEDANCES OF PULP MILL CRITERION 1 h
12007	WRIGHT/WATER ST	WINDSOR	357	0.0	0.0	0.0	0.6	2.0	7.9	1.0	34	10	1
12016	COLLEGE/SOUTH ST	WINDSOR	357	0.0	0.0	0.0	0.4	1.6	5.7	0.7	32	4	1
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	362	0.0	0.0	0.0	0.3	0.9	5.7	0.6	17	8	0
18007	CONCESSION RD 2 LOT A	TIVERTON	352	0.0	0.0	0.0	0.0	0.3	1.0	0.1	7	1	0
22904	WALPOLE S PS, SANDUSK RD	NANTICOKE	342	0.0	0.0	0.0	0.4	0.9	3.6	0.6	26	3	0
22907	RAINHAM RD (NEAR STELCO GATE)	NANTICOKE	331	0.0	0.0	0.2	0.8	3.9	15.0	1.6	55	11	13
26069	PARK/DUKE	ELMIRA	350	0.0	0.0	0.0	0.5	1.3	6.8	0.8	148	13	4
27051	HOLY T CHURCH, NORTON/PORTAGE	CHIPPAWA	39	0.0	0.0	0.1	0.9	2.6	5.6	INS	20	4	0
27055	STP GROUNDS, STANLEY AV	NIAGARA FALLS	338	0.0	0.0	0.0	0.5	2.3	17.0	1.3	180	22	33
27077	CHIPPAWA PKWY/REILLY	CHIPPAWA	113	0.0	0.0	0.0	0.0	1.0	3.3	INS	11	3	0
29000	ELGIN/KELLY ST	HAMILTON	360	0.0	0.0	0.3	0.7	1.8	7.7	1.1	47	8	2
29025	BARTON/WENTWORTH	HAMILTON	360	0.0	0.0	0.4	0.9	2.6	7.7	1.2	19	9	0
29102	467 BEACH BLVD	HAMILTON	340	0.0	0.0	0.3	0.9	2.9	12.6	1.5	51	12	15
29105	NASH RD/KENTLEY DR	HAMILTON	312	0.0	0.0	0.3	0.8	1.9	4.4	1.0	11	4	0
29114	VICKERS RD/EAST 18TH ST	HAMILTON	348	0.0	0.0	0.0	0.5	1.2	4.7	0.7	26	8	0
29118	MAIN ST W/HWY403	HAMILTON	355	0.0	0.0	0.0	0.4	1.8	5.7	0.7	16	6	0
29547	PIER 25	HAMILTON	294	0.0	0.1	0.9	1.9	5.5	20.9	2.7	355	27	49
29561	HOMESIDE	HAMILTON	153	0.0	0.3	0.6	0.9	1.8	4.8	INS	118	12	5
44015	BRONTE RD/WOBURN CRES	OAKVILLE	346	0.0	0.0	0.5	0.9	2.1	6.3	1.3	122	20	6
46117	MEADOWOOD PARK	MISSISSAUGA	356	0.0	0.0	0.2	0.6	1.2	2.6	0.7	11	3	0
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	359	0.0	0.7	1.6	2.6	4.3	10.5	2.5	109	16	4
56068	SCHOOL, 435 SECOND ST W	CORNWALL	354	0.0	0.1	0.7	1.5	4.7	19.0	2.2	78	12	41
61027	35 VAN HORNE AV	DRYDEN	364	0.0	0.0	0.0	0.0	0.8	6.2	0.4	22	4	0
62030	PORTAGE/CHURCH ST	FORT FRANCES	360	0.0	0.0	0.0	0.8	7.3	26.1	2.4	98	18	76
62032	CEMETERY,COLONIZATION RD W	FORT FRANCES	359	0.0	0.0	0.0	0.0	2.5	19.2	1.2	86	17	24
62047	EIGHTH ST/CORNWALL AVE	FORT FRANCES	344	0.0	0.0	0.0	0.4	5.3	33.9	2.3	91	31	152
62051	110 VICTORIA AVE (HOSP)	FORT FRANCES	355	0.0	0.0	0.0	0.0	2.0	13.9	0.9	58	9	11
63033	WATER TOWER	MARATHON	362	0.0	0.0	0.0	0.0	1.9	15.9	0.9	60	9	18
63046	CAN-CAR, MONTREAL ST	THUNDER BAY	355	0.0	0.0	0.0	0.6	2.9	13.5	1.2	39	9	8
63084	RECREATION CENTRE	RED ROCK	345	0.0	0.0	0.0	0.4	9.8	43.2	3.2	92	42	250
63090	ST MARTIN SCHOOL	TERRACE BAY	361	0.0	0.0	0.0	0.0	2.6	17.5	1.1	89	17	30
63092	TERRACE HEIGHTS DR	TERRACE BAY	45	0.0	0.0	0.0	0.0	2.0	21.7	INS	53	16	9
63093	MILL RD/SOUTH CAMP RD	TERRACE BAY	307	0.0	0.0	0.0	0.5	5.7	28.8	2.1	126	22	85
63200	MTC 615 JAMES ST S	THUNDER BAY	362	0.0	0.0	0.0	0.0	0.7	3.6	0.3	11	2	0
71068	WM. MERRIFIELD SCHOOL	SAULT STE MARIE	338	0.0	0.0	0.0	0.1	0.9	4.9	0.5	35	3	2
72084	ROSS RD	SMOOTH ROCK FALLS	91	0.0	0.0	0.0	0.4	0.9	3.8	INS	15	3	0
77203	SCIENCE NORTH	SUDBURY	341	0.0	0.0	0.0	0.4	0.9	2.0	0.5	5	3	0

TABLE C-9 CARBON MONOXIDE (CO) STATISTICS (1994)

UNIT = PARTS/MILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	8h	NUMBER OF TIMES ABOVE CRITERIA 1 h	8 h
12008	467 UNIVERSITY AV W	WINDSOR	362	0.0	0.2	0.5	0.7	1.1	2.8	1.0	10	6	0	0
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	356	0.0	0.0	0.0	0.0	0.5	1.2	0.2	5	4	0	0
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	359	0.0	0.0	0.0	0.4	0.8	1.9	0.5	7	5	0	0
26060	WEST AVE/HOMEWOOD	KITCHENER	360	0.0	0.0	0.0	0.0	0.7	1.9	0.3	9	6	0	0
27067	ARGYLE CRES (PUMP STN)	ST CATHARINES	356	0.0	0.0	0.0	0.2	0.8	1.8	0.4	6	3	0	0
29000	ELGIN/KELLY ST	HAMILTON	347	0.0	0.1	0.4	0.7	0.9	1.9	0.8	7	3	0	0
29118	MAIN ST W/HWY403	HAMILTON	362	0.0	0.0	0.2	0.5	0.9	2.0	0.7	6	4	0	0
31049	MISSION, 381 YONGE ST	TORONTO	249	0.1	0.5	0.9	1.5	2.7	5.9	1.7	12	7	0	0
31103	BAY/GROSVENOR	TORONTO	360	0.0	0.2	0.5	0.7	1.0	2.0	1.0	10	4	0	0
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	302	0.0	0.0	0.3	0.6	0.9	2.3	0.8	7	4	0	0
33003	LAWRENCE/KENNEDY	SCARBOROUGH	355	0.0	0.2	0.5	0.7	1.1	2.6	1.0	11	7	0	0
34020	HENDON AVE (YONGE/FINCH)	NORTH YORK	358	0.0	0.1	0.4	0.7	1.2	2.6	0.9	7	6	0	0
35003	ELMCREST RD (CENTENNIAL PK)	ETOBICOKE	351	0.0	0.0	0.3	0.6	0.9	2.7	0.7	8	5	0	0
35033	EVANS/ARNOLD AV	ETOBICOKE	359	0.1	0.3	0.6	0.8	1.5	2.9	1.2	8	6	0	0
36030	CLEARVIEW HTGS/KEELE ST	YORK	361	0.0	0.0	0.3	0.7	1.2	3.7	0.9	10	8	0	0
44008	HWY2/NORTH SHORE BLVD E	BURLINGTON	363	0.0	0.0	0.2	0.5	0.9	1.7	0.7	6	4	0	0
44015	BRONTE RD/WOBURN CRES	OAKVILLE	356	0.0	0.0	0.2	0.5	0.9	1.9	0.7	12	5	0	0
45025	PS, RITSON RD/OLIVE AV	OSHAWA	360	0.0	0.3	0.5	0.8	1.0	3.0	1.0	13	7	0	0
46110	QUEENSWAY W/HURONTARIO ST	MISSISSAUGA	345	0.0	0.0	0.3	0.7	1.1	3.6	0.8	16	5	0	0
51001	MCD GDS, RIDEAU/WURTEMBURG ST	OTTAWA	364	0.0	0.1	0.4	0.6	0.9	1.9	0.8	10	4	0	0
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	364	0.0	0.0	0.0	0.4	0.9	2.0	0.5	9	4	0	0
63046	CAN-CAR, MONTREAL ST	THUNDER BAY	354	0.0	0.0	0.0	0.1	0.8	1.9	0.4	5	4	0	0
63200	MTC 615 JAMES ST S	THUNDER BAY	356	0.0	0.0	0.0	0.0	0.6	1.9	0.3	8	5	0	0
77203	SCIENCE NORTH	SUDBURY	353	0.0	0.0	0.0	0.0	0.0	1.0	0.1	5	3	0	0

TABLE C-10 TOTAL HYDROCARBON (THC) STATISTICS (1994)

UNIT = PARTS/MILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	24 h
31103	BAY/GROSVENOR	TORONTO	90	1.19	1.68	1.93	2.24	2.73	3.37	INS	3.8	3.2
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	288	1.54	1.70	1.81	1.99	2.36	3.54	1.95	6.0	3.4
35033	EVANS/ARNOLD AV	ETOBICOKE	195	1.87	2.05	2.21	2.35	2.65	3.46	INS	4.6	3.3
44015	BRONTE RD/WOBURN CRES	OAKVILLE	347	1.35	1.65	1.89	2.18	2.71	4.15	2.04	11.0	4.3
46117	MEADOW PK, APPLE LANE CLUB	MISSISSAUGA	145	1.42	1.54	1.65	1.79	2.18	3.34	INS	10.1	3.7

TABLE C-11

NITROGEN DIOXIDE (NO2) STATISTICS (1994)

UNIT = PARTS/MILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	24 h	NUMBER OF TIMES ABOVE CRITERIA 1 h	24 h
12008	467 UNIVERSITY AV W	WINDSOR	363	0.002	0.013	0.021	0.029	0.044	0.069	0.028	0.18	0.10	0	0
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	362	0.000	0.005	0.011	0.019	0.030	0.047	0.018	0.08	0.04	0	0
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	360	0.004	0.011	0.016	0.023	0.035	0.054	0.023	0.11	0.06	0	0
15013	PUC BLDG	PARKHILL	362	0.000	0.000	0.003	0.007	0.014	0.029	0.008	0.06	0.03	0	0
22071	EXPERIMENTAL FARM	SIMCOE	261	0.000	0.000	0.000	0.001	0.008	0.020	0.004	0.04	0.02	0	0
22086	CHEAPSIDE RD(3 KM S OF HWY 3)	NANTICOKE	338	0.000	0.001	0.005	0.008	0.015	0.035	0.010	0.06	0.04	0	0
26060	WEST AVE/HOMEWOOD	KITCHENER	355	0.000	0.003	0.007	0.012	0.023	0.039	0.014	0.07	0.04	0	0
26069	PARK/DUKE	ELMIRA	174	0.000	0.001	0.005	0.008	0.018	0.034	INS	0.06	0.03	0	0
27067	ARGYLE CRES (PUMP STN)	ST CATHARINES	357	0.000	0.005	0.009	0.016	0.027	0.046	0.017	0.08	0.05	0	0
29000	ELGIN/KELLY ST	HAMILTON	361	0.003	0.009	0.015	0.022	0.033	0.055	0.022	0.12	0.06	0	0
29102	467 BEACH BLVD	HAMILTON	344	0.001	0.010	0.017	0.025	0.036	0.054	0.023	0.09	0.06	0	0
29114	VICKERS RD/EAST 18TH ST	HAMILTON	327	0.001	0.006	0.010	0.018	0.030	0.048	0.018	0.09	0.05	0	0
29118	MAIN ST W/HWY403	HAMILTON	351	0.002	0.007	0.013	0.020	0.033	0.054	0.020	0.10	0.07	0	0
31049	MISSION, 381 YONGE ST	TORONTO	249	0.014	0.023	0.030	0.038	0.052	0.075	0.037	0.11	0.08	0	0
31103	BAY/GROSVENOR	TORONTO	363	0.010	0.017	0.024	0.030	0.040	0.059	0.030	0.09	0.06	0	0
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	296	0.006	0.015	0.022	0.030	0.046	0.069	0.029	0.13	0.06	0	0
33003	LAWRENCE/KENNEDY	SCARBOROUGH	355	0.002	0.009	0.016	0.023	0.035	0.055	0.022	0.10	0.07	0	0
34020	HENDON AVE (YONGE/FINCH)	NORTH YORK	359	0.000	0.005	0.013	0.022	0.035	0.055	0.020	0.09	0.06	0	0
35003	ELMCREST RD (CENTENNIAL PK)	ETOBICOKE	357	0.004	0.013	0.020	0.028	0.040	0.062	0.027	0.09	0.07	0	0
35033	EVANS/ARNOLD AV	ETOBICOKE	358	0.010	0.017	0.023	0.029	0.039	0.058	0.029	0.10	0.07	0	0
36030	CLEARVIEW HTGS/KEELE ST	YORK	360	0.005	0.013	0.020	0.028	0.040	0.064	0.027	0.10	0.07	0	0
44008	HWY2/NORTH SHORE BLVD E	BURLINGTON	362	0.003	0.009	0.015	0.021	0.032	0.049	0.021	0.09	0.06	0	0
44015	BRONTE RD/WOBURN CRES	OAKVILLE	354	0.001	0.006	0.011	0.017	0.027	0.040	0.017	0.10	0.04	0	0
45025	PS, RITSON RD/OLIVE AV	OSHAWA	360	0.000	0.004	0.011	0.019	0.031	0.051	0.018	0.10	0.05	0	0
46110	QUEENSWAY W/HURONTARIO ST	MISSISSAUGA	347	0.003	0.009	0.015	0.022	0.035	0.056	0.022	0.10	0.06	0	0
48002	HWY47/E OF HWY48	STOUFFVILLE	307	0.000	0.000	0.004	0.009	0.019	0.037	0.010	0.08	0.05	0	0
51001	MCD GDS, RIDEAU/WURTEMBURG ST	OTTAWA	360	0.001	0.006	0.010	0.018	0.032	0.064	0.019	0.12	0.07	0	0
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	362	0.000	0.000	0.002	0.007	0.018	0.039	0.009	0.08	0.04	0	0
63200	MTC 615 JAMES ST S	THUNDER BAY	361	0.000	0.002	0.006	0.012	0.024	0.040	0.013	0.06	0.03	0	0
71068	WM. MERRIFIELD SCHOOL	SAULT STE MARIE	354	0.000	0.000	0.004	0.009	0.022	0.039	0.011	0.07	0.05	0	0
77203	SCIENCE NORTH	SUDBURY	336	0.000	0.001	0.005	0.009	0.018	0.038	0.011	0.08	0.03	0	0

TABLE C-12

NITRIC OXIDE (NO) STATISTICS (1994)

UNIT = PARTS/MILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	24 h
12008	467 UNIVERSITY AV W	WINDSOR	363	0.000	0.001	0.006	0.010	0.009	0.114	0.017	0.86	0.26
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	362	0.000	0.000	0.000	0.005	0.004	0.070	0.009	0.44	0.10
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	360	0.000	0.002	0.006	0.009	0.006	0.145	0.018	0.59	0.26
15013	PUC BLDG	PARKHILL	362	0.000	0.000	0.000	0.000	0.001	0.017	0.002	0.09	0.02
22071	EXPERIMENTAL FARM	SIMCOE	261	0.000	0.000	0.000	0.000	0.000	0.009	0.001	0.04	0.01
22086	CHEAPSIDE RD(3 KM S OF HWY 3)	NANTICOKE	338	0.000	0.000	0.000	0.000	0.001	0.027	0.002	0.09	0.04
26060	WEST AVE/HOMEWOOD	KITCHENER	355	0.000	0.000	0.000	0.002	0.005	0.110	0.008	0.48	0.18
26069	PARK/DUKE	ELMIRA	174	0.000	0.000	0.000	0.000	0.003	0.045	INS	0.32	0.08
27067	ARGYLE CRES (PUMP STN)	ST CATHARINES	357	0.000	0.000	0.000	0.002	0.005	0.144	0.010	0.47	0.16
29000	ELGIN/KELLY ST	HAMILTON	361	0.000	0.000	0.005	0.010	0.005	0.162	0.018	0.47	0.18
29102	467 BEACH BLVD	HAMILTON	344	0.000	0.000	0.008	0.023	0.004	0.155	0.024	0.40	0.19
29114	VICKERS RD/EAST 18TH ST	HAMILTON	327	0.000	0.000	0.000	0.003	0.004	0.084	0.008	0.41	0.07
29118	MAIN ST W/HWY403	HAMILTON	351	0.000	0.000	0.006	0.016	0.006	0.245	0.027	0.55	0.25
31049	MISSION, 381 YONGE ST	TORONTO	249	0.010	0.022	0.035	0.054	0.005	0.219	0.052	0.50	0.19
31103	BAY/GROSVENOR	TORONTO	363	0.000	0.005	0.011	0.022	0.004	0.132	0.025	0.39	0.21
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	296	0.000	0.000	0.000	0.008	0.007	0.176	0.017	0.67	0.14
33003	LAWRENCE/KENNEDY	SCARBOROUGH	355	0.000	0.002	0.009	0.021	0.008	0.185	0.026	0.81	0.42
34020	HENDON AVE (YONGE/FINCH)	NORTH YORK	359	0.000	0.000	0.002	0.010	0.005	0.142	0.017	0.49	0.23
35003	ELMCREST RD (CENTENNIAL PK)	ETOBICOKE	357	0.000	0.000	0.004	0.012	0.005	0.236	0.023	0.54	0.27
35033	EVANS/ARNOLD AV	ETOBICOKE	358	0.000	0.006	0.017	0.033	0.009	0.280	0.039	0.85	0.42
36030	CLEARVIEW HTGS/KEELE ST	YORK	360	0.000	0.000	0.006	0.015	0.009	0.295	0.028	0.88	0.49
44008	HWY2/NORTH SHORE BLVD E	BURLINGTON	362	0.000	0.000	0.005	0.012	0.006	0.165	0.019	0.60	0.21
44015	BRONTE RD/WOBURN CRES	OAKVILLE	354	0.000	0.000	0.002	0.008	0.005	0.151	0.015	0.52	0.20
45025	PS, RITSON RD/OLIVE AV	OSHAWA	360	0.000	0.001	0.006	0.010	0.007	0.163	0.019	0.70	0.29
46110	QUEENSWAY W/HURONTARIO ST	MISSISSAUGA	347	0.000	0.001	0.007	0.018	0.006	0.261	0.026	0.64	0.31
48002	HWY47/E OF HWY48	STOUFFVILLE	307	0.000	0.000	0.000	0.005	0.003	0.050	0.007	0.29	0.11
51001	MCD GDS, RIDEAU/WURTEMBURG ST	OTTAWA	360	0.000	0.000	0.000	0.006	0.003	0.099	0.011	0.30	0.10
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	362	0.000	0.000	0.000	0.000	0.007	0.093	0.006	0.66	0.13
63200	MTC 615 JAMES ST S	THUNDER BAY	361	0.000	0.000	0.000	0.006	0.005	0.130	0.012	0.48	0.13
71068	WM. MERRIFIELD SCHOOL	SAULT STE MARIE	354	0.000	0.000	0.000	0.000	0.003	0.088	0.007	0.26	0.07
77203	SCIENCE NORTH	SUDBURY	336	0.000	0.000	0.000	0.001	0.003	0.059	0.005	0.28	0.04

TABLE C-13

NITROGEN OXIDES (NOx) STATISTICS (1994)

UNIT = PARTS/MILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	24 h
12008	467 UNIVERSITY AV W	WINDSOR	363	0.006	0.019	0.029	0.042	0.074	0.169	0.042	0.97	0.36
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	362	0.002	0.008	0.016	0.027	0.050	0.110	0.028	0.51	0.13
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	360	0.008	0.016	0.023	0.034	0.065	0.196	0.038	0.70	0.32
15013	PUC BLDG	PARKHILL	362	0.000	0.001	0.005	0.008	0.018	0.042	0.011	0.12	0.05
22071	EXPERIMENTAL FARM	SIMCOE	261	0.000	0.000	0.000	0.005	0.010	0.030	0.006	0.08	0.03
22086	CHEAPSIDE RD(3 KM S OF HWY 3)	NANTICOKE	338	0.000	0.002	0.005	0.009	0.019	0.054	0.012	0.13	0.08
26060	WEST AVE/HOMEWOOD	KITCHENER	355	0.002	0.006	0.010	0.018	0.039	0.145	0.023	0.52	0.21
26069	PARK/DUKE	ELMIRA	174	0.001	0.004	0.007	0.011	0.025	0.066	INS	0.31	0.11
27067	ARGYLE CRES (PUMP STN)	ST CATHARINES	357	0.002	0.007	0.014	0.023	0.049	0.180	0.028	0.50	0.20
29000	ELGIN/KELLY ST	HAMILTON	361	0.006	0.015	0.024	0.037	0.072	0.205	0.040	0.52	0.24
29102	467 BEACH BLVD	HAMILTON	344	0.002	0.016	0.033	0.051	0.085	0.187	0.046	0.53	0.23
29114	VICKERS RD/EAST 18TH ST	HAMILTON	327	0.003	0.008	0.015	0.025	0.050	0.128	0.028	0.48	0.11
29118	MAIN ST W/HWY403	HAMILTON	351	0.005	0.014	0.023	0.042	0.104	0.283	0.048	0.62	0.31
31049	MISSION, 381 YONGE ST	TORONTO	249	0.031	0.052	0.071	0.096	0.148	0.287	0.088	0.58	0.24
31103	BAY/GROSVENOR	TORONTO	363	0.017	0.029	0.041	0.058	0.091	0.181	0.054	0.70	0.26
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	296	0.008	0.018	0.028	0.043	0.082	0.232	0.045	0.77	0.19
33003	LAWRENCE/KENNEDY	SCARBOROUGH	355	0.006	0.019	0.032	0.050	0.094	0.234	0.050	0.91	0.50
34020	HENDON AVE (YONGE/FINCH)	NORTH YORK	359	0.001	0.009	0.020	0.038	0.078	0.188	0.038	0.59	0.29
35003	ELMCREST RD (CENTENNIAL PK)	ETOBICOKE	357	0.007	0.017	0.028	0.045	0.095	0.288	0.049	0.61	0.33
35033	EVANS/ARNOLD AV	ETOBICOKE	358	0.015	0.031	0.046	0.067	0.124	0.320	0.068	0.93	0.49
36030	CLEARVIEW HTGS/KEELE ST	YORK	360	0.011	0.019	0.030	0.048	0.105	0.348	0.055	0.96	0.56
44008	HWY2/NORTH SHORE BLVD E	BURLINGTON	362	0.005	0.014	0.023	0.037	0.073	0.205	0.040	0.65	0.27
44015	BRONTE RD/WOBURN CRES	OAKVILLE	354	0.003	0.011	0.018	0.029	0.063	0.180	0.034	0.56	0.23
45025	PS, RITSON RD/OLIVE AV	OSHAWA	360	0.003	0.010	0.020	0.035	0.071	0.212	0.037	0.77	0.34
46110	QUEENSWAY W/HURONTARIO ST	MISSISSAUGA	347	0.010	0.019	0.029	0.046	0.091	0.310	0.050	0.74	0.36
48002	HWY47/E OF HWY48	STOUFFVILLE	307	0.002	0.009	0.015	0.020	0.035	0.088	0.023	0.37	0.16
51001	MCD GDS, RIDEAU/WURTEMBURG ST	OTTAWA	360	0.002	0.007	0.014	0.025	0.055	0.145	0.028	0.34	0.14
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	362	0.000	0.001	0.006	0.012	0.030	0.129	0.017	0.72	0.16
63200	MTC 615 JAMES ST S	THUNDER BAY	361	0.000	0.005	0.010	0.020	0.049	0.171	0.025	0.49	0.16
71068	WM. MERRIFIELD SCHOOL	SAULT STE MARIE	354	0.000	0.000	0.007	0.016	0.039	0.123	0.019	0.30	0.12
77203	SCIENCE NORTH	SUDBURY	336	0.000	0.004	0.007	0.012	0.026	0.097	0.017	0.34	0.08

TABLE C-14

OZONE (O3) STATISTICS (1994)

UNIT = PARTS/BILLION

STATION NUMBER	LOCATION	CITY	NO. OF DAYS	PERCENTILES 10	30	50	70	90	99	ARITH. MEAN	MAXIMUM 1 h	24 h	NO. OF TIMES ABOVE CRITERION 1 h
12008	467 UNIVERSITY AV W	WINDSOR	334	0.6	6.4	14.0	23.0	38.8	72.0	18.0	139	59	40
12016	COLLEGE/SOUTH ST	WINDSOR	356	0.0	6.4	15.1	24.5	43.1	76.8	19.3	137	70	62
13021	MOEE WATER PUMP STN, MIDDLE RD	MERLIN	361	6.7	14.9	21.2	28.4	43.7	72.0	24.2	100	62	29
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	362	1.8	11.5	19.8	27.5	39.4	68.4	21.4	101	54	25
14118	CONCESSION RD 26	MANDAUMIN	352	5.7	15.4	22.8	30.0	42.2	73.7	24.6	114	60	49
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	353	2.8	12.5	20.7	28.6	44.9	69.6	23.1	95	62	27
15009	LONGWOODS CONSERVATION	LONGWOODS	335	6.8	18.1	26.3	34.6	50.0	77.2	28.3	98	62	57
15013	PUC BLDG	PARKHILL	360	8.5	19.7	27.2	34.0	47.9	77.2	28.6	107	65	69
15020	WATER TREATMENT PLANT	GRAND BEND	363	9.3	21.7	29.5	36.2	48.3	76.7	30.2	112	62	63
18007	CONCESSION RD 2 LOT A	TIVERTON	364	13.9	24.4	31.0	36.1	48.0	75.9	31.7	102	70	64
22071	EXPERIMENTAL FARM	SIMCOE	356	10.2	20.6	27.5	35.7	52.5	79.2	30.2	103	77	77
22901	PROVINCIAL PARK	LONG POINT	337	11.6	21.9	29.1	37.2	55.5	91.2	32.2	158	96	174
26060	WEST AVE/HOMEWOOD	KITCHENER	361	2.9	14.0	22.1	30.5	45.8	74.2	24.4	94	65	35
27067	ARGYLE CRES (PUMP STN)	ST CATHARINES	345	1.0	12.6	21.8	30.5	46.2	68.7	23.6	111	62	13
27072	STANLEY AVE/HWY 420	NIAGARA FALLS	346	4.3	15.1	22.9	31.5	49.3	77.3	25.8	105	65	62
28028	EXHIBITION ST/CLARK ST	GUELPH	354	1.8	13.1	20.9	29.3	43.7	68.9	23.1	97	58	19
29000	ELGIN/KELLY ST	HAMILTON	361	0.0	6.2	13.8	22.0	36.9	63.6	17.0	96	65	13
29105	NASH RD/KENTLEY DR	HAMILTON	356	0.0	8.5	17.0	25.6	41.8	69.1	20.0	126	64	21
29114	VICKERS RD/EAST 18TH ST	HAMILTON	362	0.4	11.3	20.0	29.3	46.0	73.5	22.9	119	73	44
29118	MAIN ST W/HWY403	HAMILTON	361	0.0	6.5	15.9	24.8	41.0	68.9	19.1	103	71	14
31103	BAY/GROSVENOR	TORONTO	363	1.0	7.2	13.6	21.8	34.7	59.8	16.9	88	57	9
31120	PERTH/RUSKIN(JUNCTION TRIANGLE)	TORONTO	302	2.3	9.1	17.7	26.5	40.5	69.4	20.6	95	50	19
33003	LAWRENCE/KENNEDY	SCARBOROUGH	338	0.6	7.6	15.8	23.9	36.7	62.9	18.2	82	51	1
34020	HENDON AVE (YONGE/FINCH)	NORTH YORK	355	0.5	6.8	16.4	25.0	39.0	67.2	18.8	98	53	13
35003	ELMCREST RD (CENTENNIAL PK)	ETOBICOKE	355	0.0	5.1	14.3	23.3	37.7	66.7	17.4	103	55	18
35033	EVANS/ARNOLD AV	ETOBICOKE	358	0.0	4.0	10.6	18.2	30.9	59.2	14.1	85	40	7
36030	CLEARVIEW HTGS/KEELE ST	YORK	359	0.4	5.4	15.2	24.3	39.2	72.2	18.4	103	52	44
44008	HWY2/NORTH SHORE BLVD E	BURLINGTON	354	2.7	11.1	20.3	29.7	45.9	77.1	23.4	110	82	59
44015	BRONTE RD/WOBURN CRES	OAKVILLE	350	0.5	10.3	21.0	30.1	43.9	70.5	22.5	95	56	26
45025	PS, RITSON RD/OLIVE AV	OSHAWA	349	4.4	13.7	22.6	30.2	42.0	68.0	23.8	122	55	26
46110	QUEENSWAY W/HURONTARIO ST	MISSISSAUGA	358	0.3	7.2	16.9	25.8	40.6	69.9	19.5	96	51	20
48002	HWY47/E OF HWY48	STOUFFVILLE	351	7.0	17.7	24.1	30.7	42.0	67.5	25.3	102	60	15
49010	HWY 117/PAINT LAKE RD	DORSET	363	11.1	22.9	29.8	35.8	46.3	69.2	30.2	95	64	27
51001	MCD GDS, RIDEAU/WURTEMBURG ST	OTTAWA	362	2.0	10.2	18.3	25.4	36.5	59.0	19.7	79	49	0
52020	CHURCHILL PK, NAPIER ST	KINGSTON	356	0.0	10.1	19.6	28.0	42.5	70.0	21.3	91	55	16
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	363	2.7	13.5	20.9	27.0	38.9	60.7	21.7	82	56	4
59006	CITY HALL, 500 GEORGE ST	PETERBOROUGH	207	9.9	20.5	26.5	32.8	42.6	69.2	INS	87	54	6
62030	PORTAGE/CHURCH ST	FORT FRANCES	362	10.4	18.0	24.6	31.1	41.0	50.7	25.6	65	55	0
62068	FERNBERG RD	ELY MINNESOTA	351	17.8	24.9	29.9	35.5	46.2	63.2	31.6	90	70	6
63120	CLOUD RIVER	THUNDER BAY	363	8.1	20.0	27.1	33.2	42.9	56.3	27.0	82	52	1
63200	MTC 615 JAMES ST S	THUNDER BAY	361	1.4	10.3	18.5	26.0	34.4	45.7	19.0	71	44	0
71068	WM MERRIFIELD SCHOOL	SAULT STE MARIE	339	4.5	14.7	23.4	29.7	39.3	57.2	23.3	84	54	2
75010	OPP STN	NORTH BAY	333	6.2	16.6	24.9	31.5	42.5	61.9	25.3	84	61	8
77203	SCIENCE NORTH	SUDBURY	345	10.2	20.2	26.3	32.3	42.4	62.3	27.1	83	59	3

TABLE C-15

TOTAL SUSPENED PARTICULATE (TSP) STATISTICS (1994)

UNIT = MICROGRAMS /CUBIC METRE

STATION NUMBER	LOCATION	CITY	NO. OF SAMPLES	PERCENTILES 10	30	50	70	90	99	MAX.	ARITH MEAN	GEOM. MEAN	NO. OF TIMES ABOVE CRITERIA 24 h	1 Yr
11001	309 THOMAS ST	ST MARYS	56	28	39	51	68	97	187	199	60	52	5	0
12005	7730 RIVERSIDE DR E	WINDSOR	42	21	32	41	50	66	88	98	43	38	0	0
12006	BEACH LANE/HWY 18	LA SALLE	55	36	45	53	61	78	106	121	55	52	1	0
12007	WRIGHT/WATER ST	WINDSOR	48	42	52	61	76	100	142	143	68	64	3	1
12008	467 UNIVERSITY AV W	WINDSOR	53	43	46	54	65	89	130	136	61	58	2	0
12009	9725 RIVERSIDE DR E LITTLE RIVER	WINDSOR	52	26	33	42	50	68	109	111	46	42	0	0
12011	DROUILLARD RD/RICHMOND ST	WINDSOR	53	38	51	59	74	94	156	162	66	62	2	1
12013	FILTRAT PLT,3665 WYANDOTTE ST E	WINDSOR	47	39	56	76	94	145	232	234	85	75	8	1
12015	SEWAGE STN, HWY 18/PROSPECT	WINDSOR	51	49	70	81	112	145	200	205	93	85	12	1
12016	COLLEGE/SOUTH ST	WINDSOR	44	33	43	51	59	76	114	129	54	51	1	0
12036	1802 GEORGE AV	WINDSOR	44	25	31	42	55	78	130	146	47	41	1	0
12037	3225 CALIFORNIA ST	WINDSOR	55	37	43	48	55	79	127	129	54	51	2	0
12038	2885 HOWARD AV	WINDSOR	54	60	79	108	120	171	215	216	108	100	15	1
12047	DORWIN PLAZA, DOUGALL AV	WINDSOR	54	33	44	52	67	83	122	133	59	55	1	0
12053	415 FRONT ST	AMHERSTBURG	47	28	38	45	54	85	103	111	50	45	0	0
12055	DUFF ST (E END)	AMHERSTBURG	49	25	35	41	50	68	102	104	45	41	0	0
12058	COLUMBUS CENTRE	AMHERSTBURG	52	35	44	55	63	96	129	137	60	55	2	0
14001	GENERAL HOSPITAL, 220 MITTON ST	SARNIA	54	25	33	40	52	75	101	105	45	41	0	0
14016	HWY40 (OPP LAMBTON GS)	COURTRIGHT	55	21	29	38	45	57	72	76	39	36	0	0
14030	RR1 (W OF HOUSE)	CORUNNA	55	20	26	33	44	56	78	80	36	34	0	0
14031	RR1 (W OF BARN)	MOORETOWN	34	23	32	42	49	76	109	118	45	40	0	0
14059	ST CLAIR BLVD/HWY 40	CORUNNA	53	24	31	37	44	58	88	96	40	37	0	0
14064	CENTENNIAL PK,FRONT ST/CN TRACKS	SARNIA	55	26	34	44	51	71	89	91	45	42	0	0
14151	DAVID/FRONT ST	SARNIA	53	27	33	42	55	77	107	116	49	43	0	0
15001	WRN FAIR GROUNDS, KING/RECTORY	LONDON	52	28	41	52	67	107	138	147	59	52	3	0
15008	EDGEWARE RD (NNW VARTA PLT)	ST THOMAS	51	24	35	43	55	79	116	118	47	41	0	0
15009	LONGWOODS CONSERVATION	LONGWOODS	52	13	20	28	38	51	56	57	30	27	0	0
15014	POND MILLS RD/DEVERON CRES	LONDON	53	24	32	38	48	71	105	110	44	40	0	0
15015	951 COMMISSIONERS RD E	LONDON	51	13	20	25	31	46	74	85	28	25	0	0
15016	801 COMMISSIONERS RD E	LONDON	46	20	25	32	42	55	86	95	36	33	0	0
15017	8 MOUNTSFIELD DR	LONDON	55	19	28	34	42	71	89	92	39	35	0	0
17014	CYANAMIDE RD (GORDON PROP)	BEACHVILLE	54	24	29	37	49	65	95	112	42	38	0	0
17015	26 VINE ST (MOE TRAILER)	BEACHVILLE	46	27	36	45	55	78	119	140	51	46	1	0
17020	HWY 2 RR 2 (J SPRIEL PROP)	INGERSOLL	44	27	50	61	73	97	144	166	62	53	1	0
17021	OXFORD CTY RD 6 (HESSTON FARM)	EMBRO	48	26	39	62	77	101	119	125	62	54	1	0
22092	RAINHAM RD/SANDUSK RD	JARVIS	46	17	24	31	41	57	73	78	34	30	0	0
22904	WALPOLE S PS, SANDUSK RD	NANTICOKE	54	15	23	27	42	51	62	62	32	29	0	0
22907	RAINHAM RD (NEAR STELCO GATE)	NANTICOKE	59	25	39	50	67	82	105	113	53	48	0	0
22961	NANTICOKE RD/WALPOLE CON 2	NANTICOKE	49	18	27	37	50	67	79	85	40	36	0	0
22964	N 2 KM NANTICOKE GS	NANTICOKE	58	15	24	28	39	53	73	81	32	28	0	0
27008	71 KING ST	ST CATHARINES	50	34	45	52	63	81	103	104	55	51	0	0
27045	337 ALBERTA/DEVON ST	WELLAND	56	21	31	39	51	65	107	126	43	39	0	0
27047	DAVIS/FRAZER	PORT COLBORNE	54	27	35	43	56	82	149	222	51	46	1	0
27052	185 QUEEN ST S	THOROLD	48	38	51	66	76	111	190	191	72	64	5	1

TABLE C-15 (cont.) TOTAL SUSPENED PARTICULATE (TSP) STATISTICS (1994)

UNIT = MICROGRAMS /CUBIC METRE

STATION NUMBER	LOCATION	CITY	NO. OF SAMPLES	PERCENTILES 10	30	50	70	90	99	MAX.	ARITH MEAN	GEOM. MEAN	NO. OF TIMES ABOVE CRITERIA 24 h	1 Yr
27055	STP GROUNDS, STANLEY AV	NIAGARA FALLS	48	36	52	71	92	126	191	191	79	69	5	1
27072	STANLEY AVE/HWY 420	NIAGARA FALLS	53	22	32	38	52	66	83	84	42	39	0	0
28027	HANLON EXPWY/SPEED RIVER	GUELPH	49	30	48	53	68	94	145	181	61	55	1	0
29000	ELGIN/KELLY ST	HAMILTON	47	33	46	58	71	117	175	204	67	60	4	0
29009	KENILWORTH	HAMILTON	51	29	41	49	58	90	128	129	55	50	2	0
29011	BURLINGTON/LEEDS	HAMILTON	59	51	62	74	87	126	168	172	81	75	8	1
29017	CHATHAM/FRID	HAMILTON	56	38	58	69	85	122	150	158	75	68	6	1
29025	BARTON/WENTWORTH	HAMILTON	58	34	45	62	78	116	144	146	66	60	5	0
29067	450 HUGHSON ST N	HAMILTON	59	26	32	39	50	65	82	83	43	40	0	0
29087	405 CUMBERLAND AV	HAMILTON	57	35	45	52	66	91	107	117	58	54	0	0
29098	BAY/MAIN ST	HAMILTON	56	27	36	42	55	74	94	101	47	44	0	0
29102	467 BEACH BLVD	HAMILTON	55	33	54	72	88	120	180	183	74	66	5	1
29105	NASH RD/KENTLEY DR	HAMILTON	54	24	36	42	50	70	87	95	44	41	0	0
29111	OFIELD RD/HWY 5	GREENSVILLE	51	38	52	69	86	108	143	144	72	65	5	1
29112	HARVEST RD/WESITE	GREENSVILLE	54	23	27	32	39	51	59	62	34	33	0	0
29113	GERTRUDE/DEPEW	HAMILTON	55	47	57	68	87	125	153	157	77	71	6	1
29114	VICKERS RD/EAST 18TH ST	HAMILTON	52	23	34	38	50	63	79	83	42	39	0	0
29118	MAIN ST W/HWY403	HAMILTON	58	23	31	38	48	63	75	76	41	39	0	0
29119	MORLEY ST/PARKDALE AV	HAMILTON	52	41	60	75	87	117	143	152	77	72	4	1
29122	DUNDURN/YORK	HAMILTON	56	22	28	37	47	59	75	77	39	36	0	0
29124	BUCHANAN PARK PS	HAMILTON	37	25	29	38	45	61	78	83	INS	INS	0	INS
29130	EWEN RD/WHITNEY AV	HAMILTON	52	22	29	35	43	58	65	65	37	35	0	0
29135	ALBRIGHT RD/MT ALBION RD	HAMILTON	57	21	28	33	41	56	70	81	36	33	0	0
29143	KEEFER COURT (MOE AIR SHOP)	HAMILTON	57	33	50	64	76	96	129	138	65	59	3	0
31045	BRUCE PS, 51 LARCHMOUNT AV	TORONTO	319	28	37	45	61	83	129	171	52	47	5	0
31058	MOSLEY/LESLIE STS	TORONTO	321	32	45	59	75	100	158	210	65	58	15	0
31065	633 EASTERN AV	TORONTO	311	30	45	59	72	97	130	150	61	56	7	0
31082	WORKS DEPT, 138 HAMILTON AV	TORONTO	310	31	44	56	72	93	130	206	60	54	8	0
31085	TECUMSETH/NIAGARA ST	TORONTO	41	30	38	49	68	85	96	99	54	49	0	0
31103	BAY/GROSVENOR	TORONTO	353	36	47	56	71	93	132	158	61	57	7	0
31183	TORONTO	TORONTO	18	25	38	48	58	78	97	99	INS	INS	0	INS
34034	111 FENMAR DR. NORTH YORK	NORTH YORK	34	49	93	116	168	202	256	258	INS	INS	17	INS
45100	91 QUEEN ST (GOODYEAR TIRE)	BOWMANVILLE	42	16	24	30	44	61	110	110	38	33	0	0
46045	2365 DIXIE RD	MISSISSAUGA	311	28	40	51	67	87	129	235	56	50	4	0
46046	2360 DIXIE RD	MISSISSAUGA	294	28	43	54	67	90	156	414	59	53	8	0
46117	MEADOWOOD PARK	MISSISSAUGA	74	17	25	33	42	63	111	114	38	33	0	0
49011	HWY 117/BELLWOOD ACRES	DORSET	58	7	10	14	21	30	45	47	17	14	0	0
62032	CEMETERY,COLONIZATION RD W	FORT FRANCES	51	9	12	19	26	41	62	66	22	18	0	0
62035	LEGION BLDG, 250 CHURCH ST	FORT FRANCES	49	16	25	41	58	83	142	155	47	38	2	0
63046	CAN-CAR, MONTREAL ST	THUNDER BAY	53	16	32	48	56	92	148	167	50	40	2	0
63200	MTC 615 JAMES ST S	THUNDER BAY	52	17	25	31	42	53	65	70	34	31	0	0
71042	PUMPHOUSE, BONNEY ST	SAULT STE MARIE	211	22	38	69	100	162	254	311	81	62	45	1
71049	LAND OFFICE, QUEEN ST	SAULT STE MARIE	59	16	23	27	33	44	64	72	29	27	0	0
71068	WM. MERRIFIELD SCHOOL	SAULT STE MARIE	108	16	25	34	46	71	119	200	42	35	1	0

TABLE C-15 (cont.) TOTAL SUSPENED PARTICULATE (TSP) STATISTICS (1994)

UNIT = MICROGRAMS /CUBIC METRE

STATION NUMBER	LOCATION	CITY	NO. OF SAMPLES	PERCENTILES 10	30	50	70	90	99	MAX.	ARITH MEAN	GEOM. MEAN	NO. OF TIMES ABOVE CRITERIA 24 h	1 Yr
71074	165 GOVERNMENT ROAD	WAWA	92	12	19	34	49	96	271	420	49	33	8	0
71075	3 MAPLE STRET	WAWA	100	10	17	22	35	54	78	110	29	24	0	0
72083	TREMBLEY ST (E OF QUIRION)	ENGLEHART	89	24	48	70	108	217	315	351	97	71	25	1
72102	KAP-KIG-WAN RD	ENGLEHART	40	15	20	24	30	37	54	59	26	24	0	0
72103	128 KING ST	ENGLEHART	42	14	22	27	32	50	73	81	30	26	0	0
72107	HOSPITAL	ENGLEHART	14	12	19	23	31	35	44	45	INS	INS	0	INS
75046	10169 LAKESHORE RD	NEW LISKEARD	84	11	19	26	39	65	115	120	34	27	0	0
77026	19 LISGAR ST	SUDBURY	53	18	25	33	39	54	74	77	34	31	0	0
77029	POST OFFICE, SPRUCE/BARBER ST	ESPANOLA	59	29	41	47	59	87	120	150	52	48	1	0
77070	PUMPHOUSE NICKEL ST.	COPPER CLIFF	59	13	22	28	32	50	65	69	29	25	0	0

TABLE C-16 INHALABLE PARTICULATE (PM10) STATISTICS (1994)

UNIT = MICROGRAMS /CUBIC METRE

STATION NUMBER	LOCATION	CITY	NO. OF SAMPLES	PERCENTILES 10	30	50	70	90	99	MAX.	ARITH MEAN	GEOM. MEAN
12507	WRIGHT/WATER ST	WINDSOR	46	19	24	30	36	55	74	79	33	31
12508	467 UNIVERSITY AVE W	WINDSOR	50	15	19	25	37	56	86	91	32	27
12513	3665 WYNDOTTE ST E	WINDSOR	47	16	22	31	43	68	94	95	37	32
15516	801 COMMISSIONER RD E	LONDON	42	10	15	17	22	36	52	52	20	18
22304	WALPOLE PS, SANDUSK RD	NANTICOKE	46	8	11	15	21	28	38	41	17	16
27308	71 KING STREET	ST CATHARINES	44	15	20	24	29	43	57	64	27	25
27352	185 QUEEN ST S	THOROLD	52	18	25	32	40	54	74	79	34	31
29300	ELGIN/KELLY ST	HAMILTON	52	14	22	26	32	48	82	96	30	26
29302	467 BEACH BLVD	HAMILTON	54	11	21	27	37	51	64	65	29	25
29313	GERTRUDE/DEPEW	HAMILTON	53	22	27	35	45	55	77	90	37	34
29324	BUCHANAN PARK PS	HAMILTON	34	13	18	22	27	34	39	39	22	20
31127	BAY/GROSVENOR ST	TORONTO	53	13	20	24	33	40	68	75	27	24
46127	MEADWOOD PARK	MISSISSAUGA	53	11	15	21	24	38	60	60	23	20
56051	MEMORIAL PK BEDFORD/THIRD	CORNWALL	53	13	18	20	26	33	43	44	22	20
62135	LEGION 250 CHURCH	FORT FRANCES	51	7	14	20	24	38	47	50	21	18
63201	615 JAMES ST S	THUNDER BAY	51	8	14	19	23	27	34	38	19	17
71342	BONNEY ST	SAULT STE MARIE	49	14	29	42	50	73	93	95	42	36
71368	WM MERRIFIELD SCHOOL	SAULT STE MARIE	60	11	16	20	28	44	59	63	24	21
77326	LISGAR ST.	SUDBURY	58	11	19	22	26	33	44	44	23	21

AIR QUALITY IN ONTARIO
1994 COMPREHENSIVE REPORT
Reader Response Form

Your comments on our annual publication, **"Air Quality in Ontario 1994 Comprehensive Report"** are important to us. Please take a few moments to fill out this short form. Your comments will be used to help us improve future reports on air quality in Ontario.

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1) What sections of the report did you like? Please explain:

2) Are there any issues not addressed in this report that you would like to see in the next air quality report? Please explain:

3) More detailed information (i.e., hourly/daily concentrations) could be made available. Would you have a need for it? YES____ NO____

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Please use the back of this page, if necessary, for any additional comments you would like to make.

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Air Quality & Meteorology Section
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THANK YOU FOR YOUR COMMENTS!